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Faust et al.

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(54) **DUCT WALL WATER EXTRACTOR**

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(73) Assignee: **Honeywell International Inc.**, Morristown, NJ (US)

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B01D 45/12 (2006.01)

(52) **U.S. Cl.** **55/394**; 55/428; 55/457

(58) **Field of Classification Search** 55/394, 55/428, 430, 457
See application file for complete search history.

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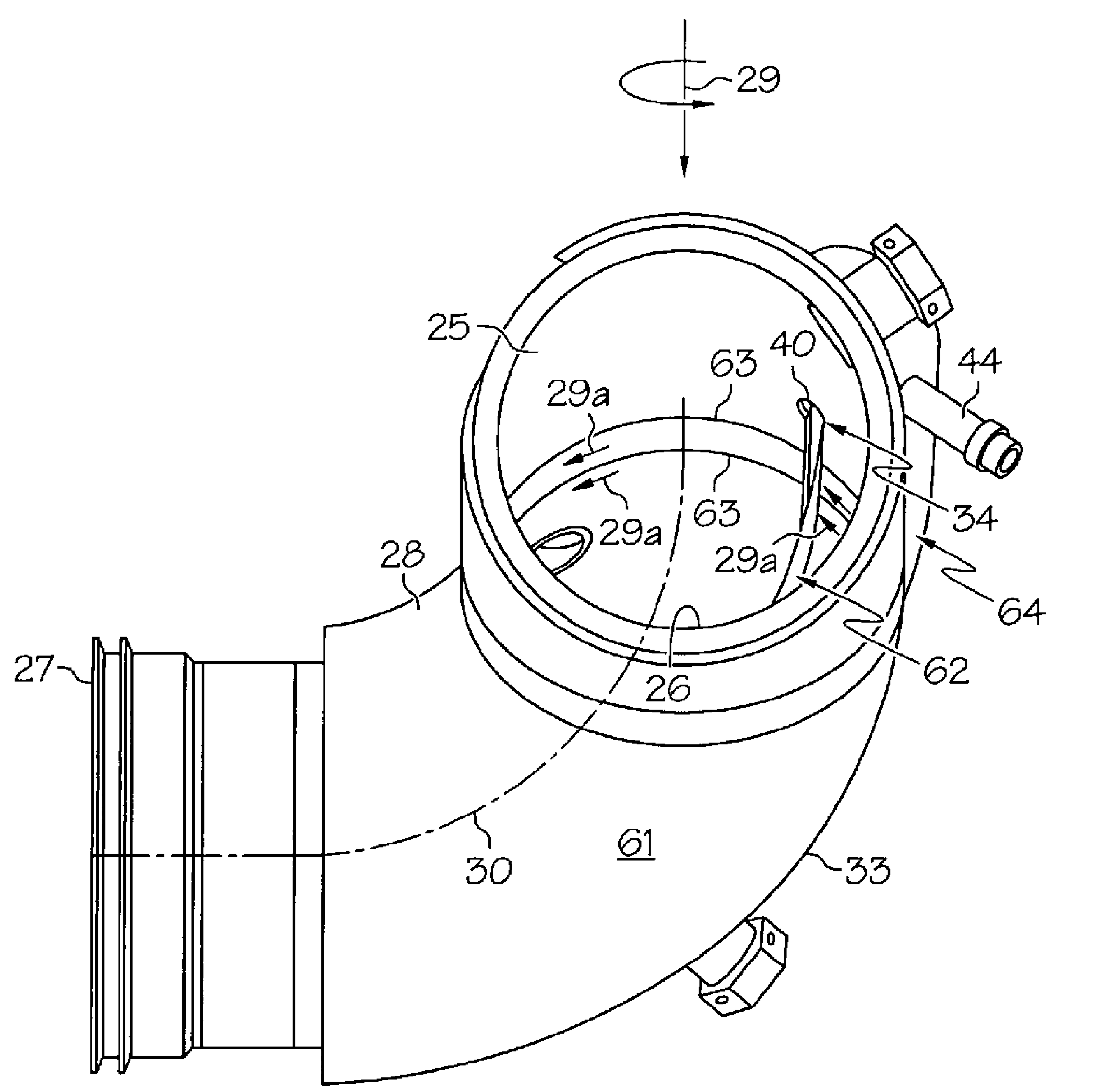
(57) **ABSTRACT**

A liquid extractor may comprise a slot in a duct wall and one or more ridges positioned on the interior duct wall surface. A bend in the duct, a swirl device and/or gravity may throw the liquid portion of the flow onto the wall surface. The slot may be oriented longitudinally along the duct. The ridge(s) may intersect the duct and be positioned to direct the liquid on the wall surface to the slot where the water is extracted. An enclosing sump may be positioned on the outside of the duct and over the slot.

24 Claims, 21 Drawing Sheets



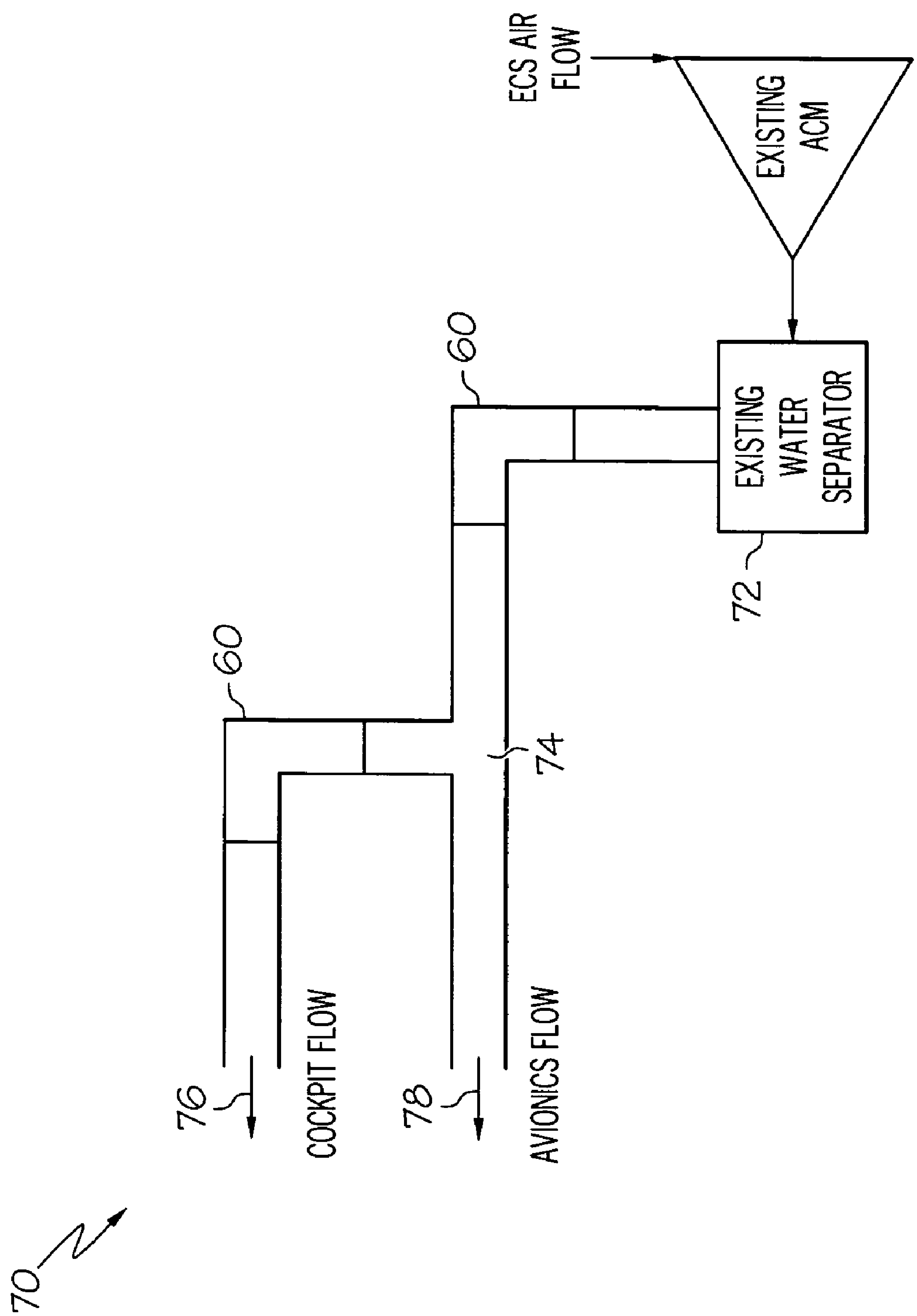

ECS AIR FLOW
EXISTING ACM
EXISTING WATER SEPARATOR
60
60
72
74
76
78
COCKPIT FLOW
AVIONICS FLOW
70

FIG. 1

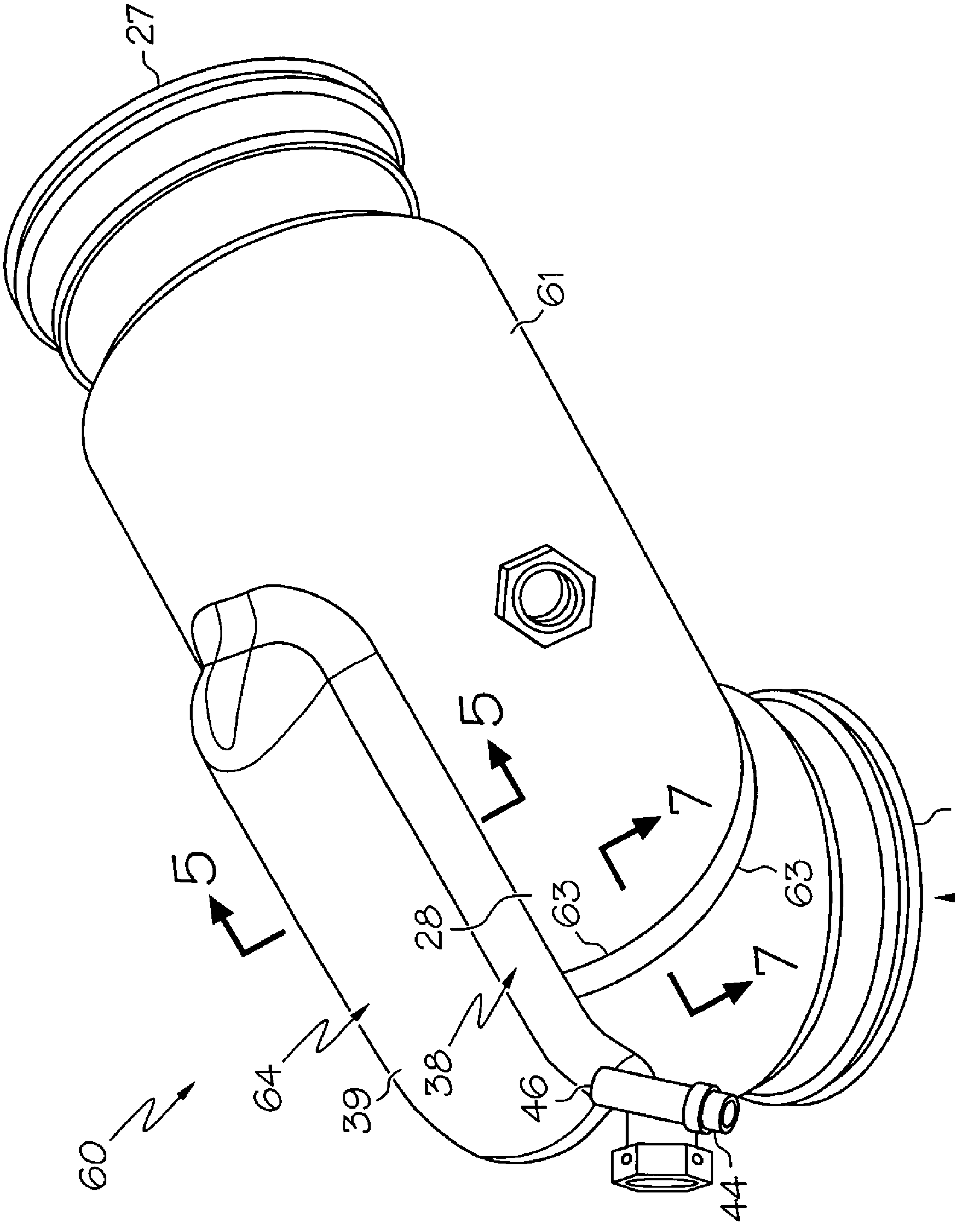


FIG. 2

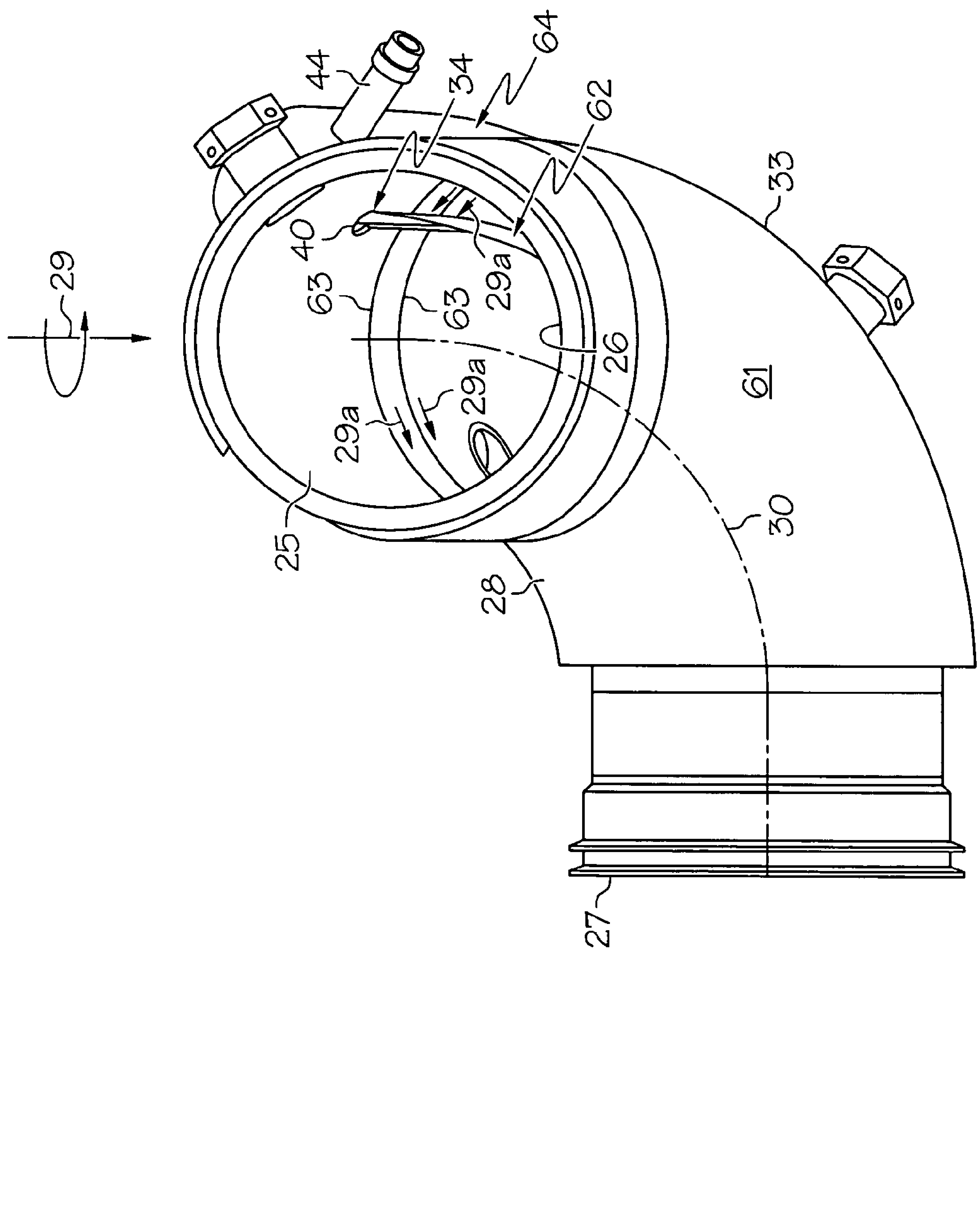


FIG. 3

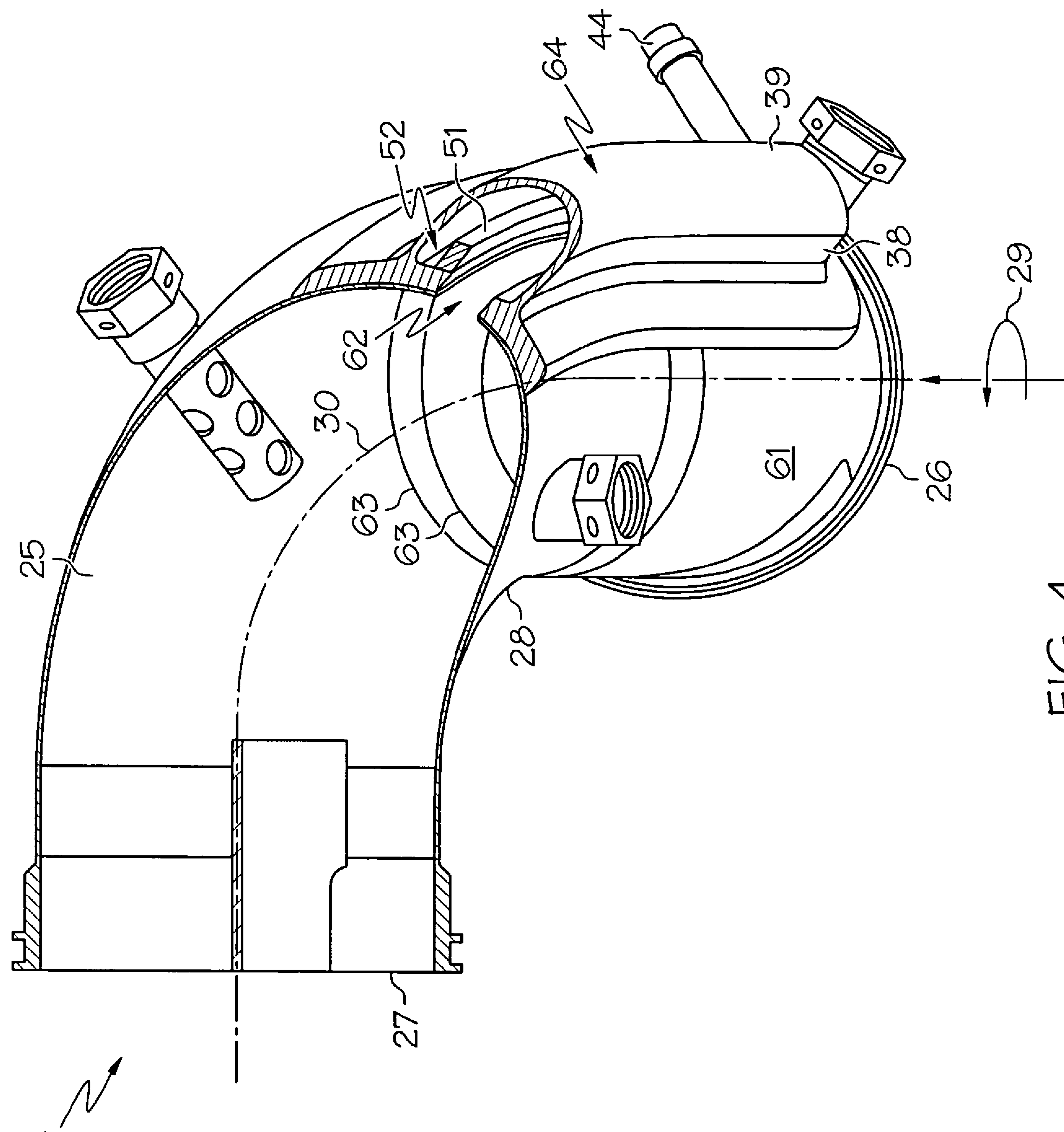


FIG. 4

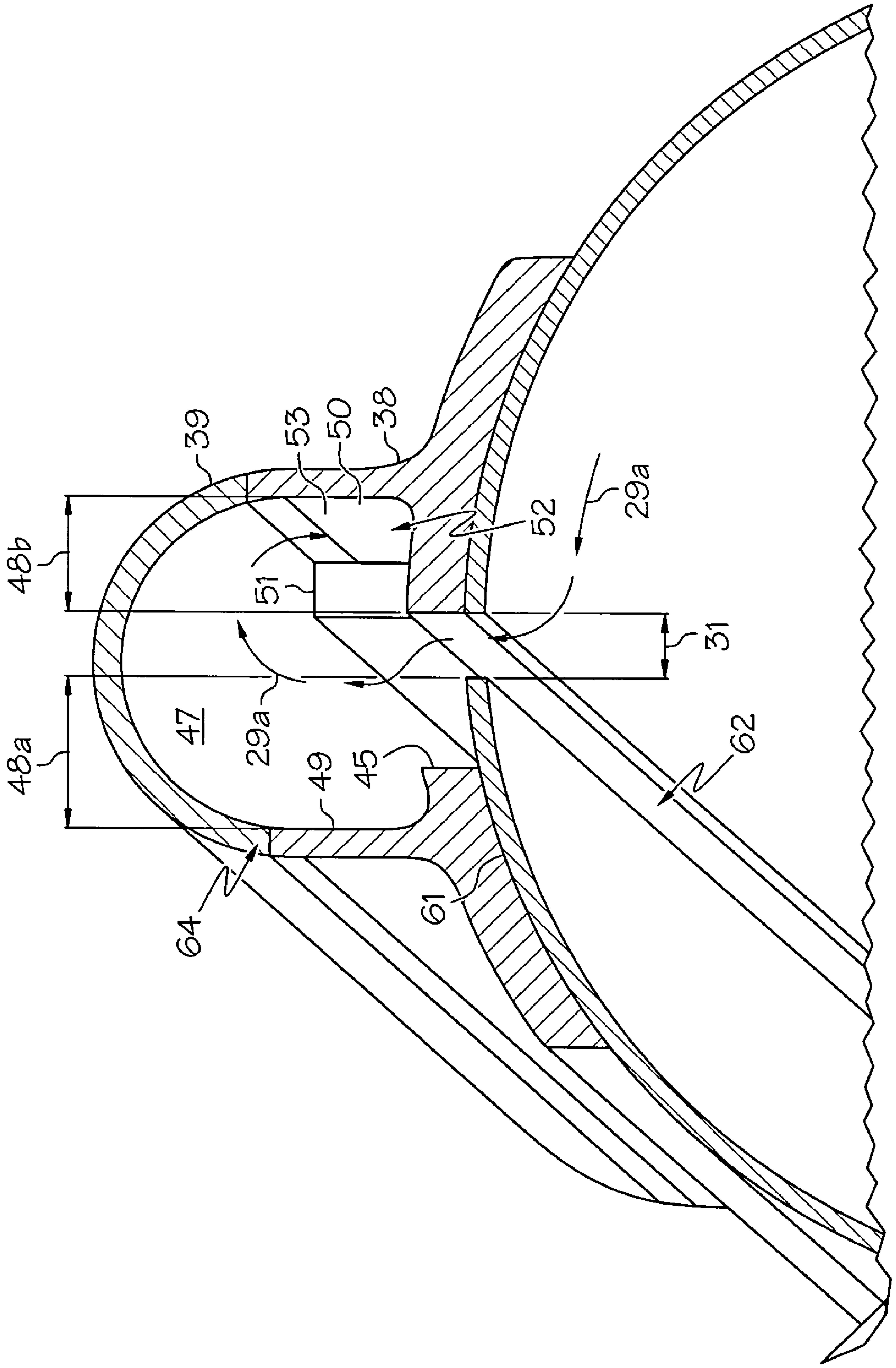


FIG. 5a

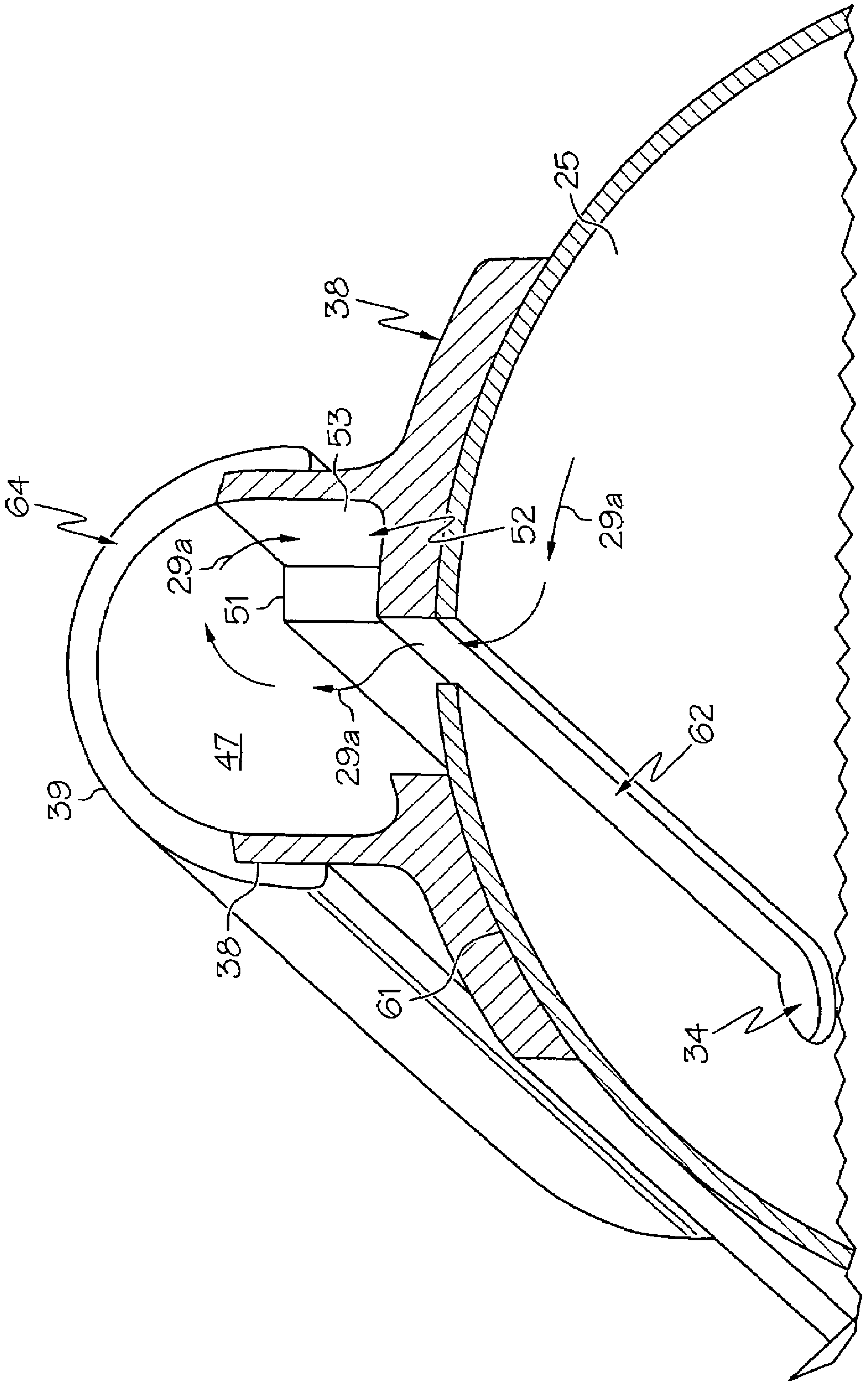


FIG. 5b

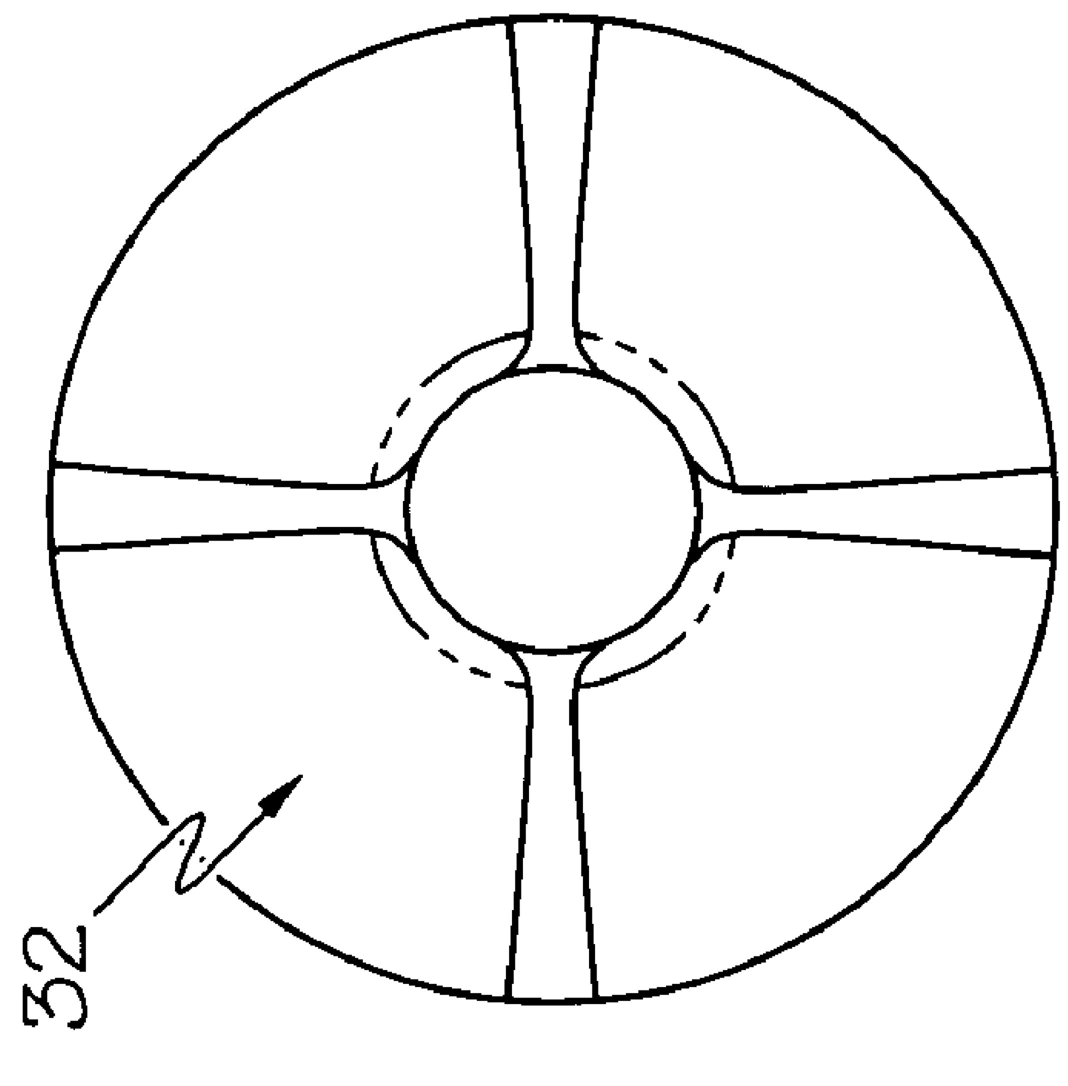


FIG. 6c

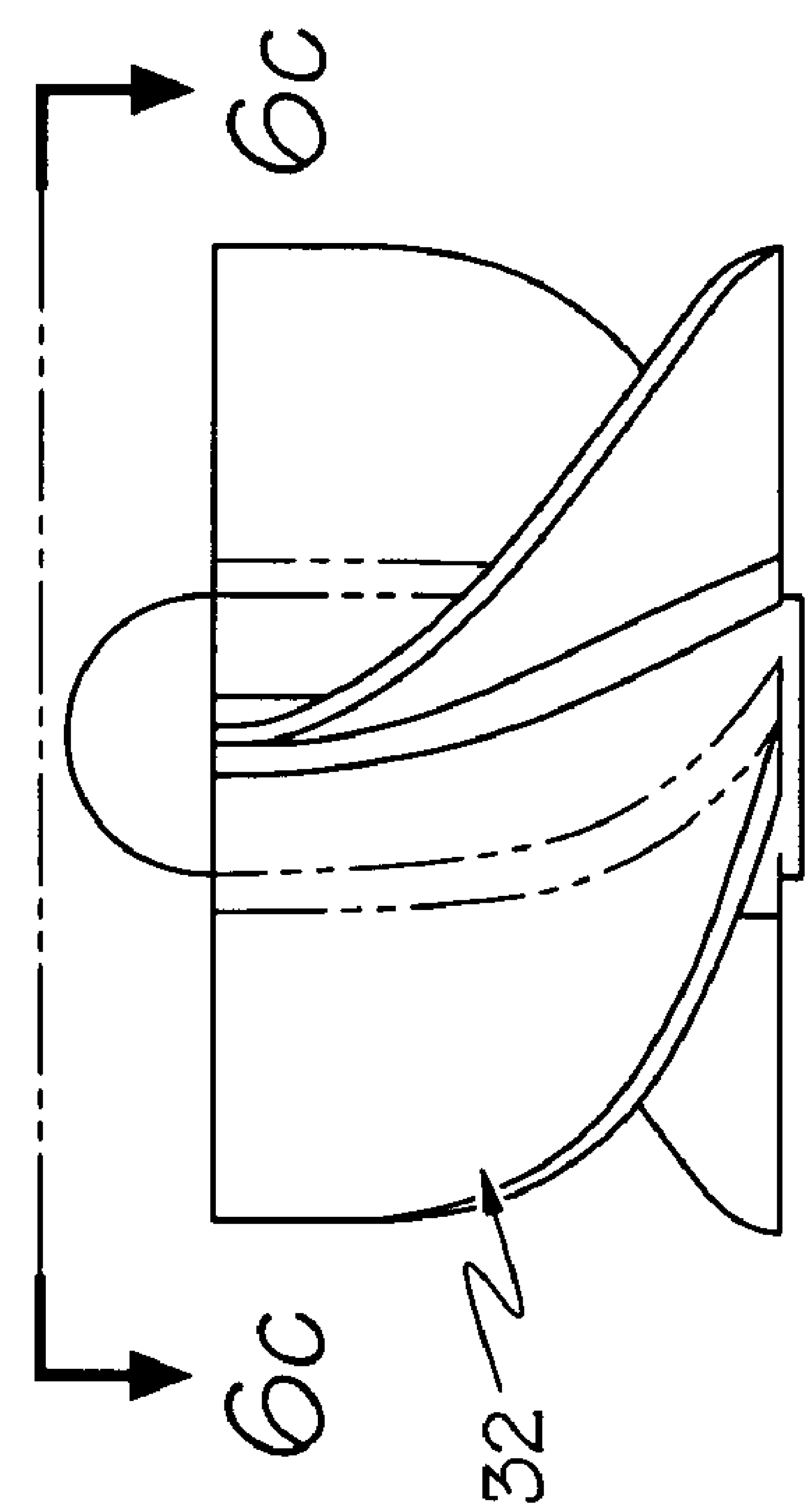


FIG. 6b

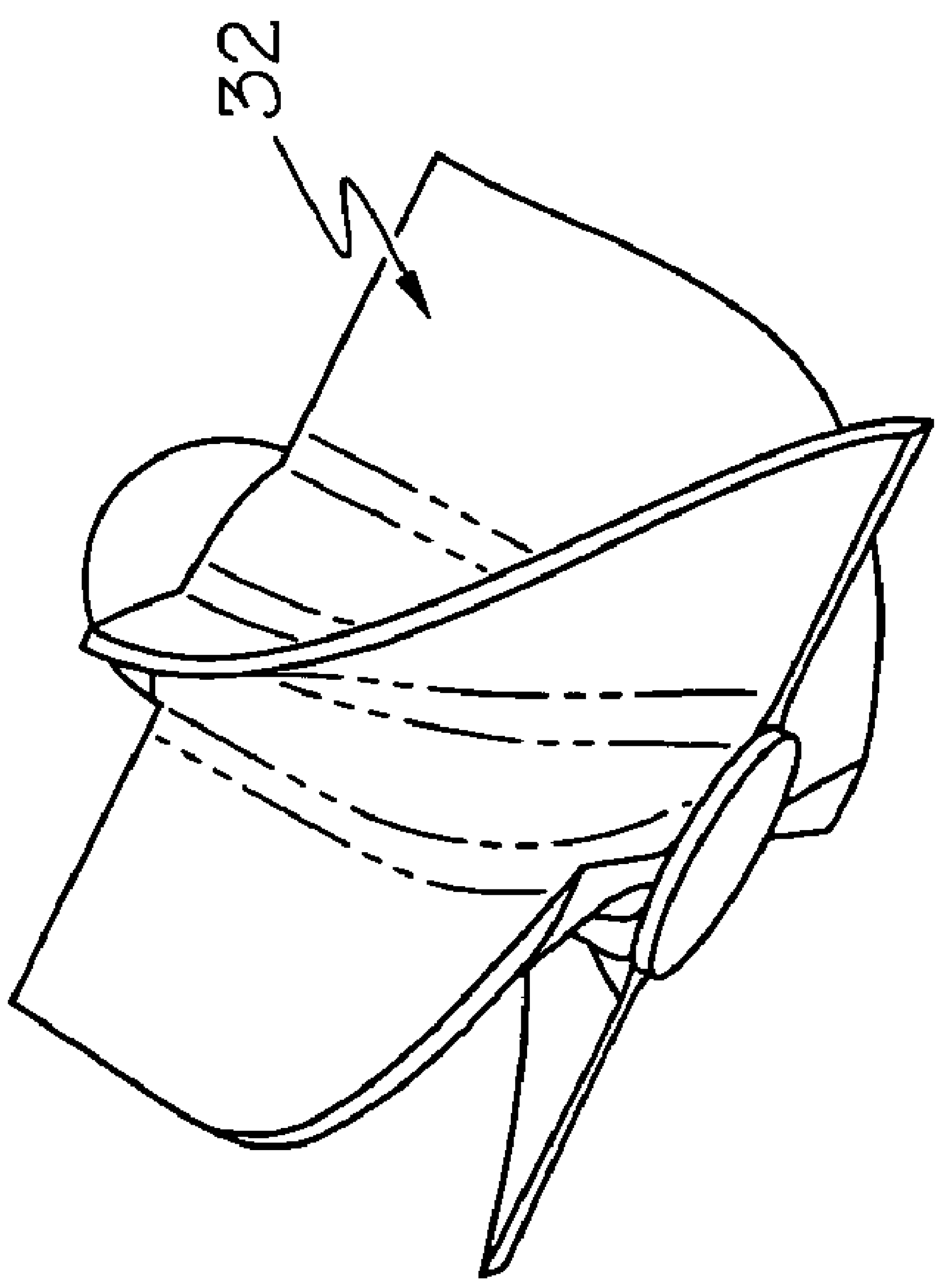


FIG. 6a

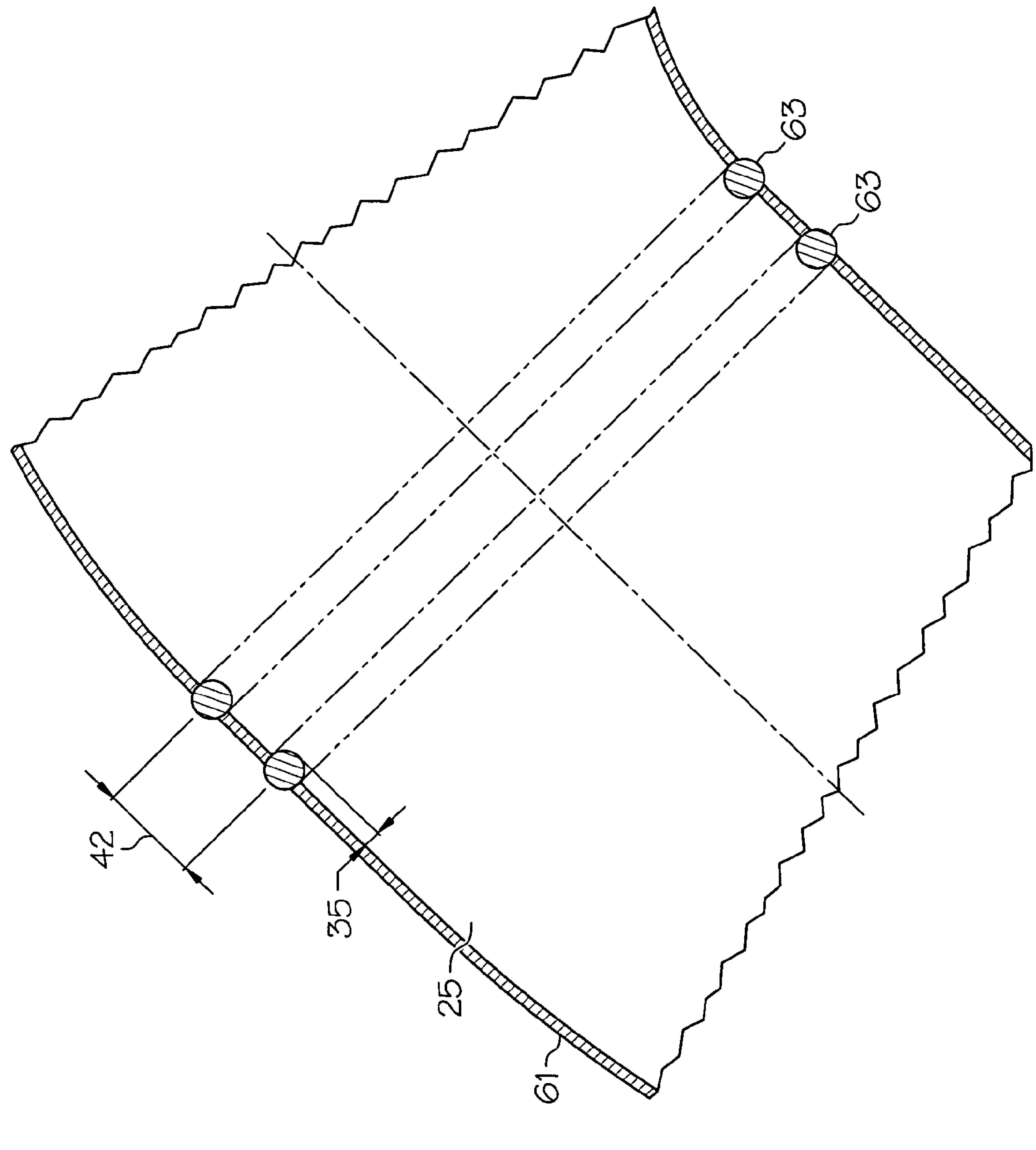


FIG. 7

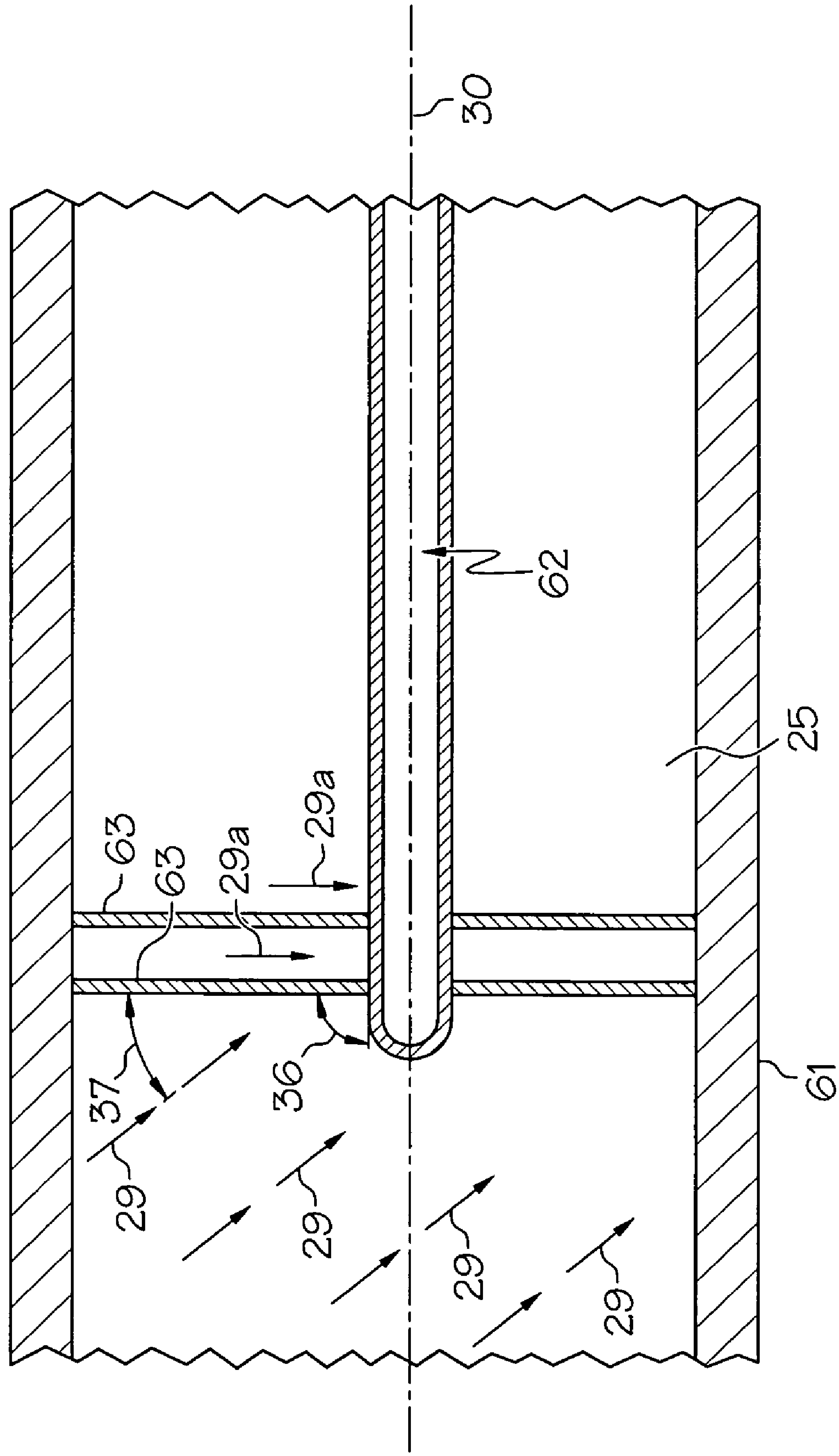


FIG. 8a

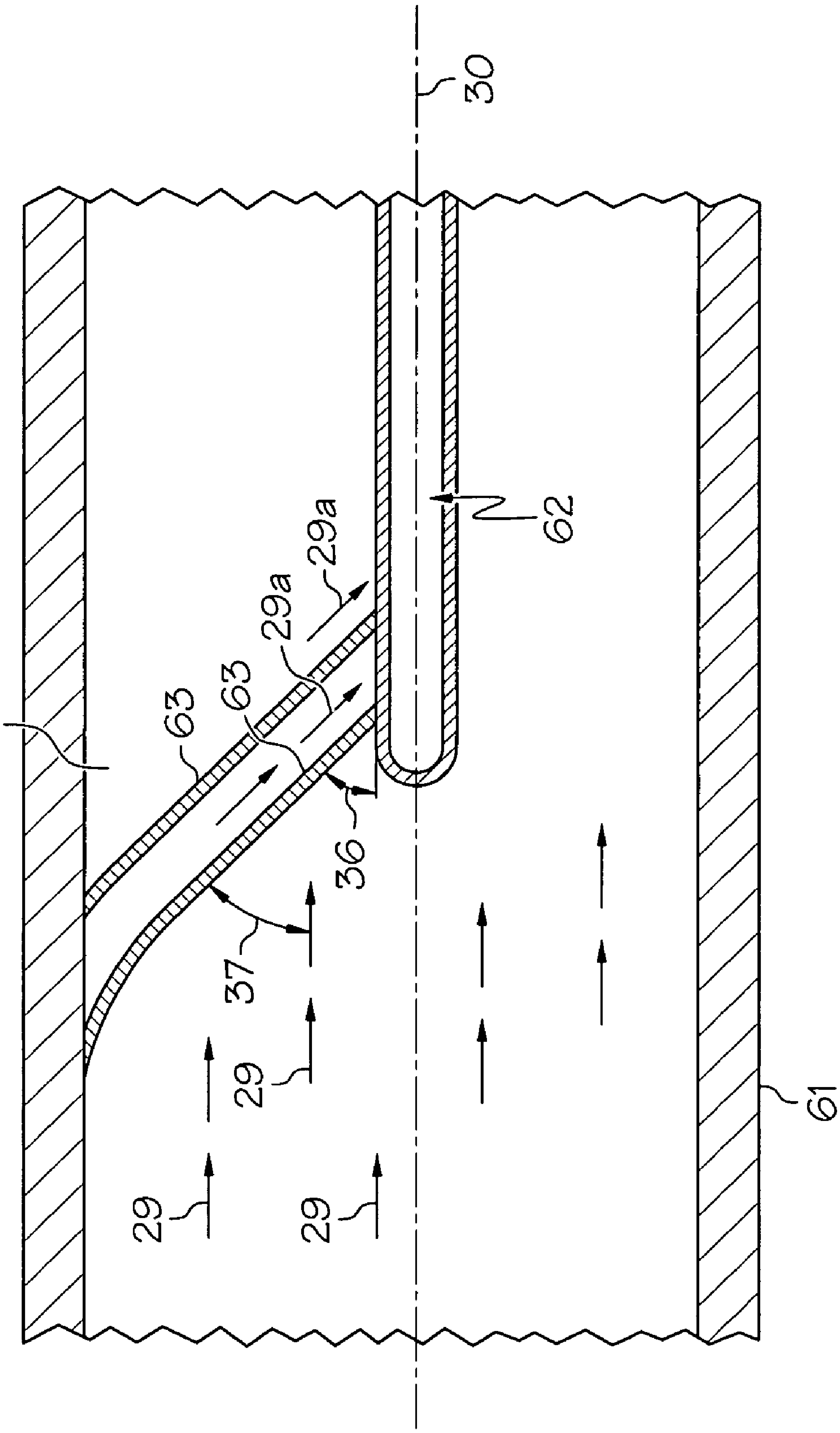


FIG. 8b

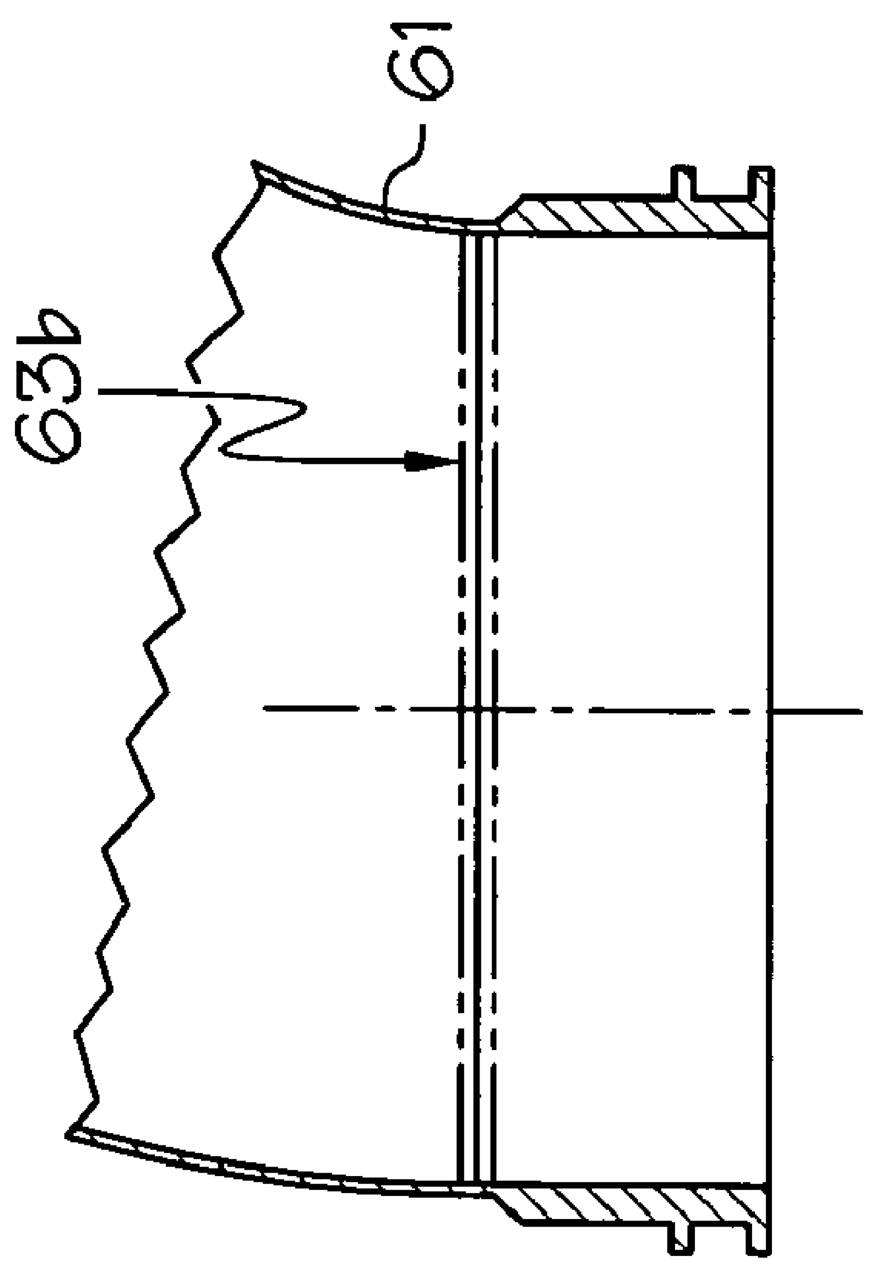


FIG. 10

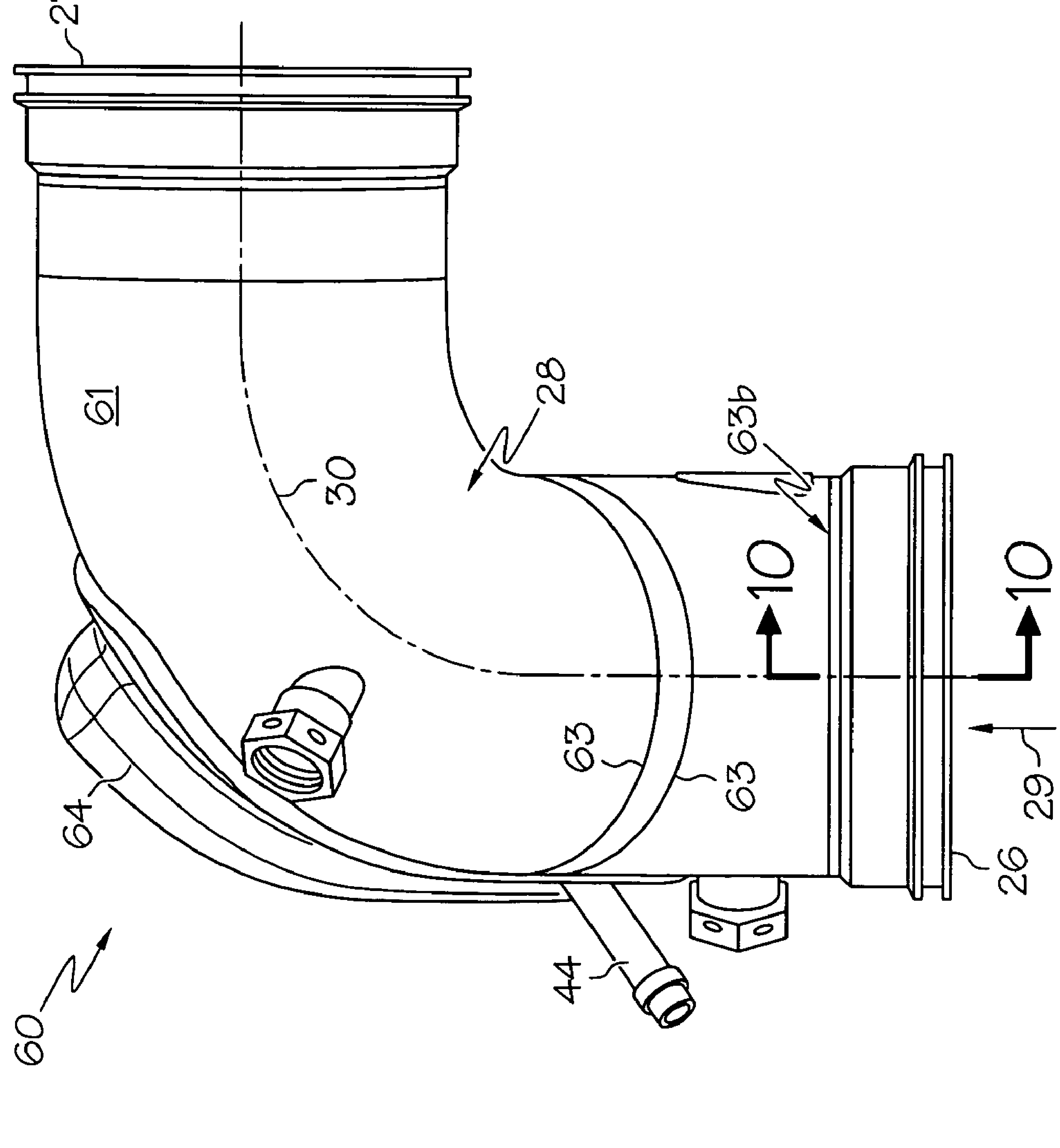


FIG. 9

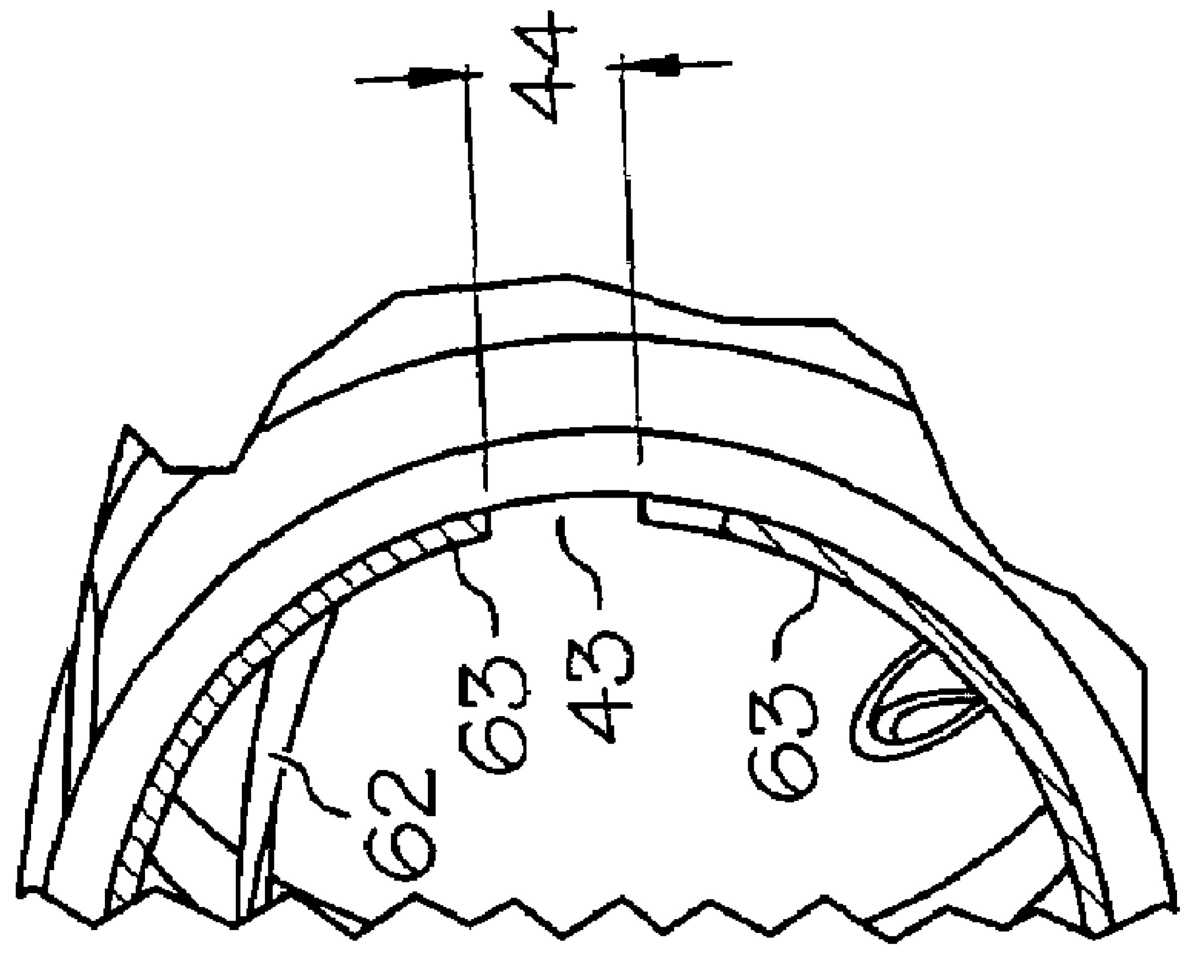


FIG. 12

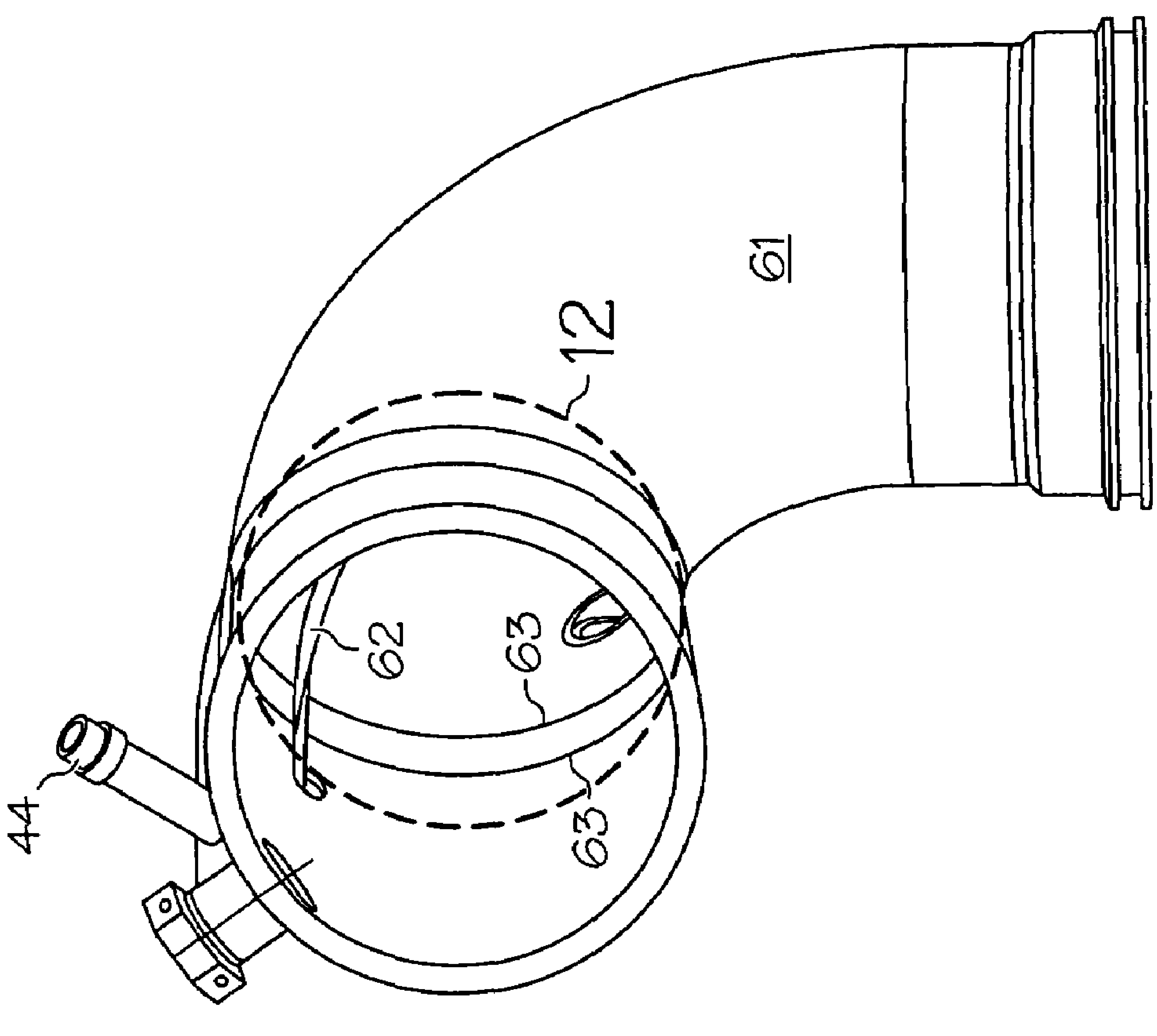


FIG. 11

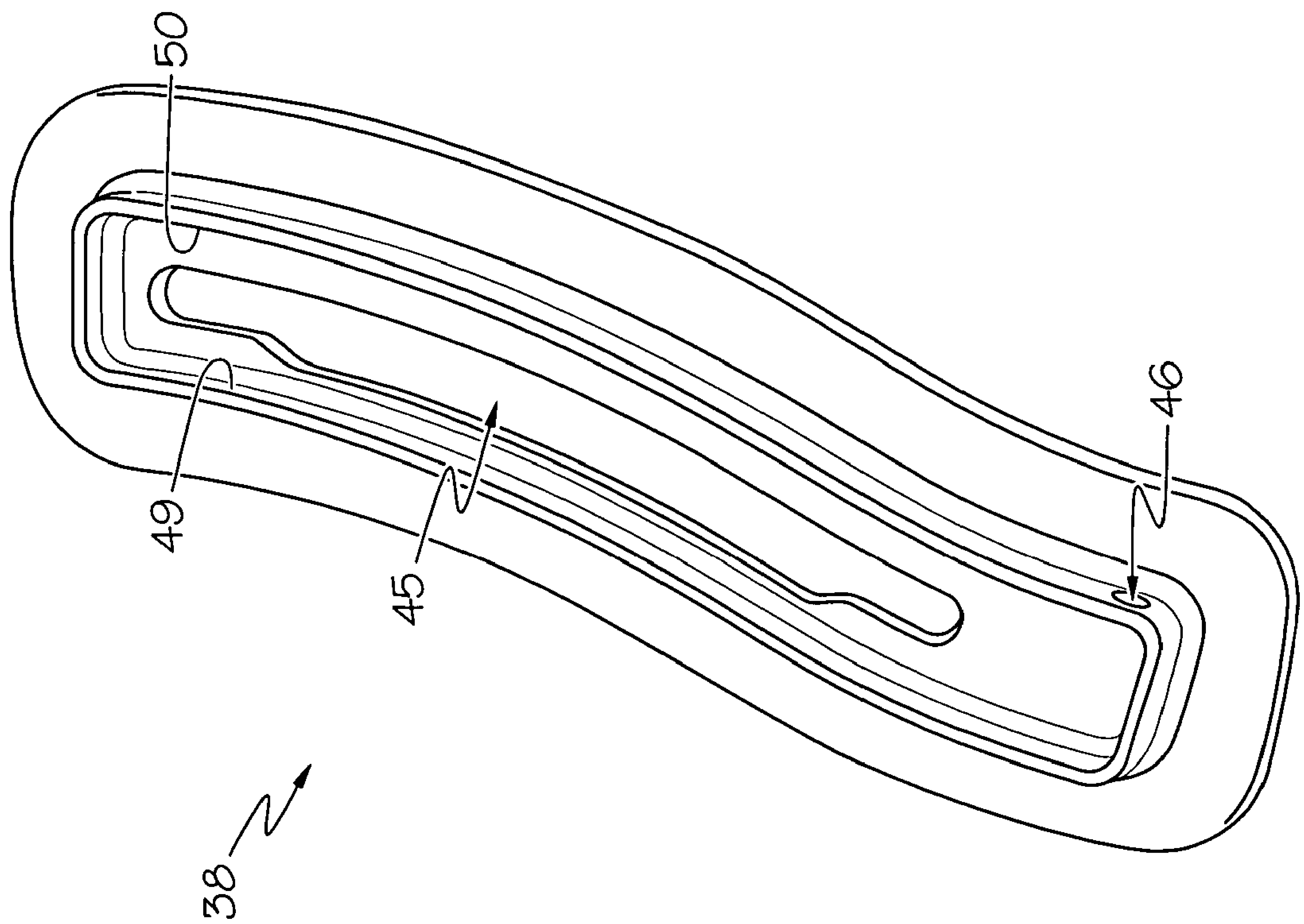


FIG. 13

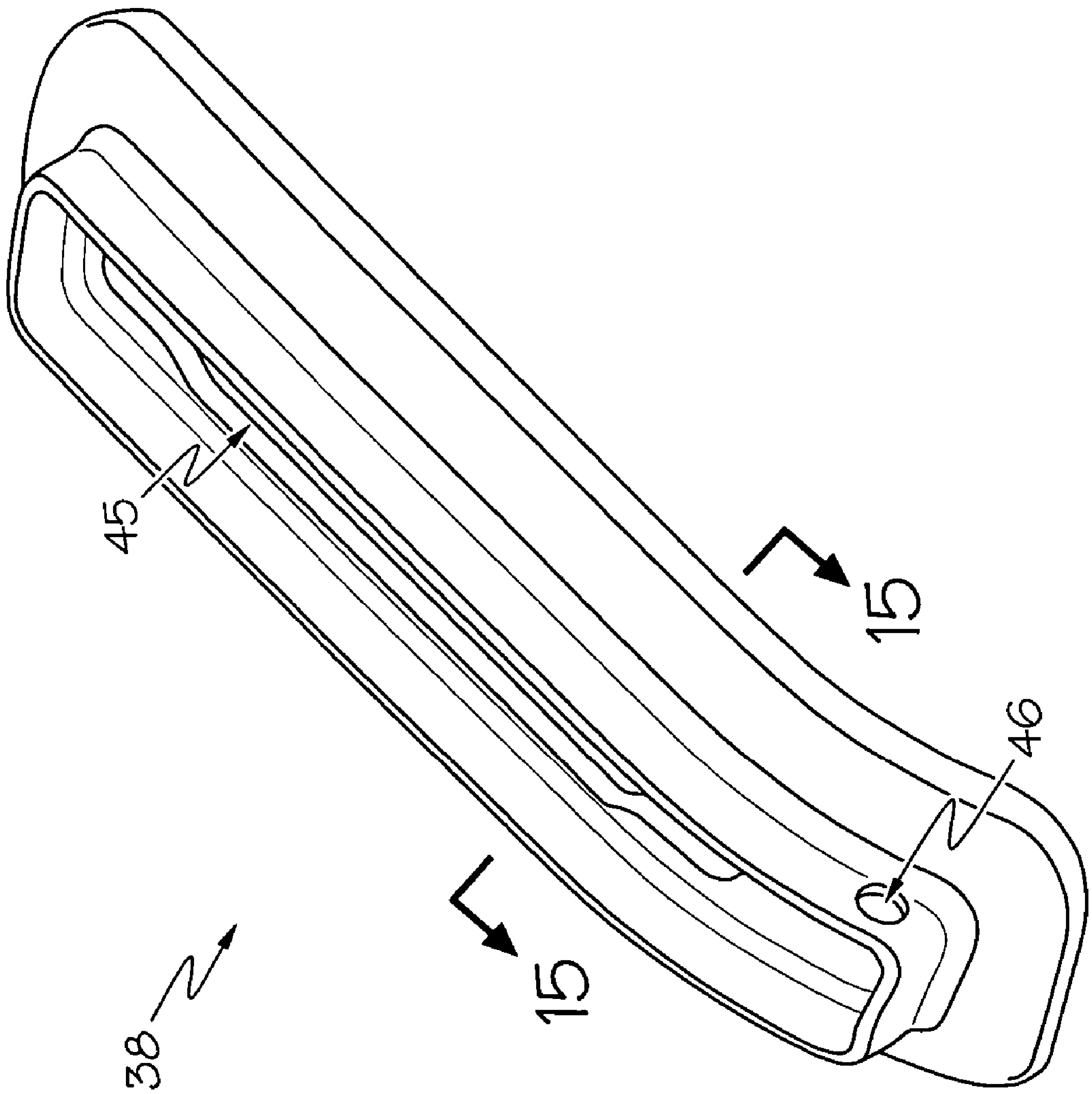


FIG. 14

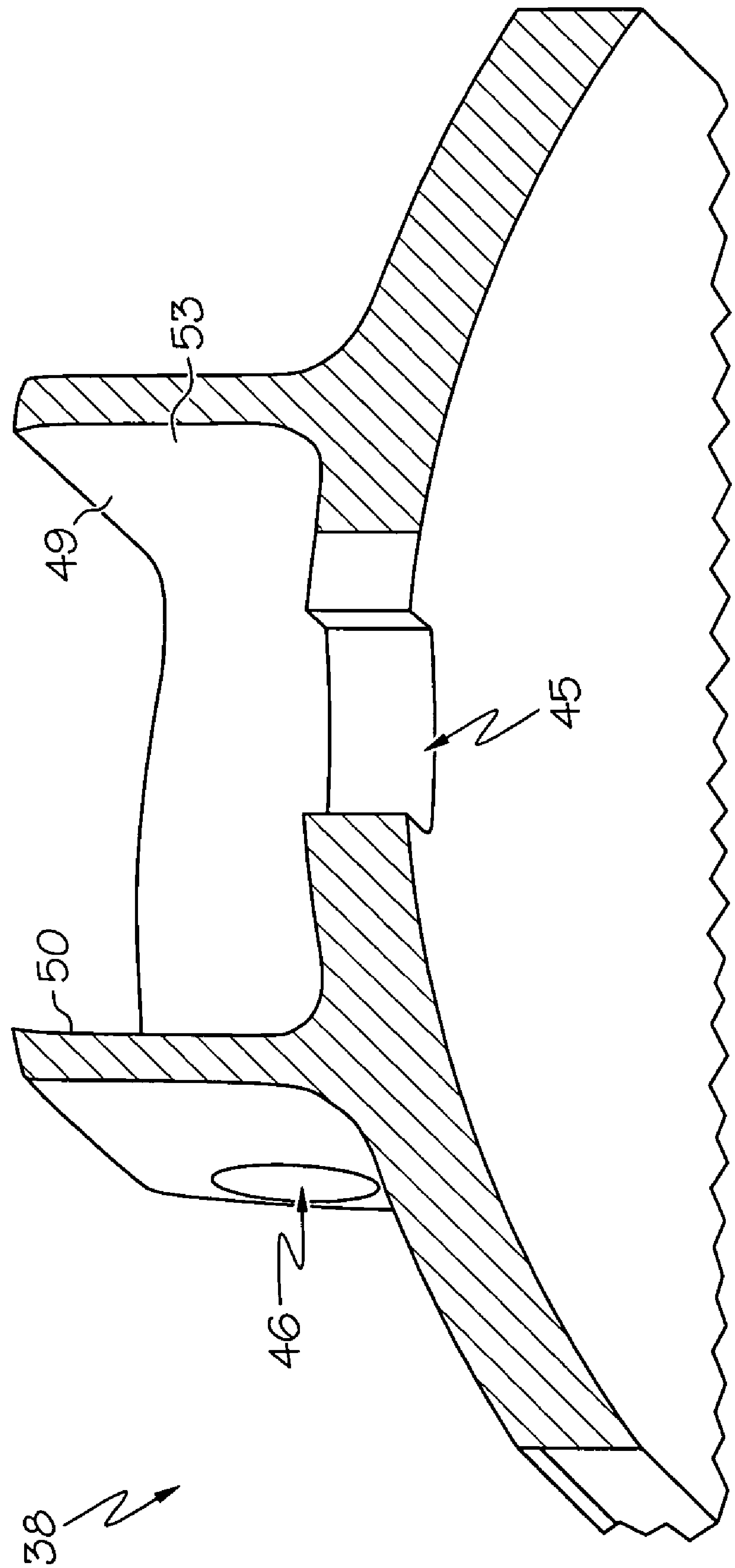


FIG. 15

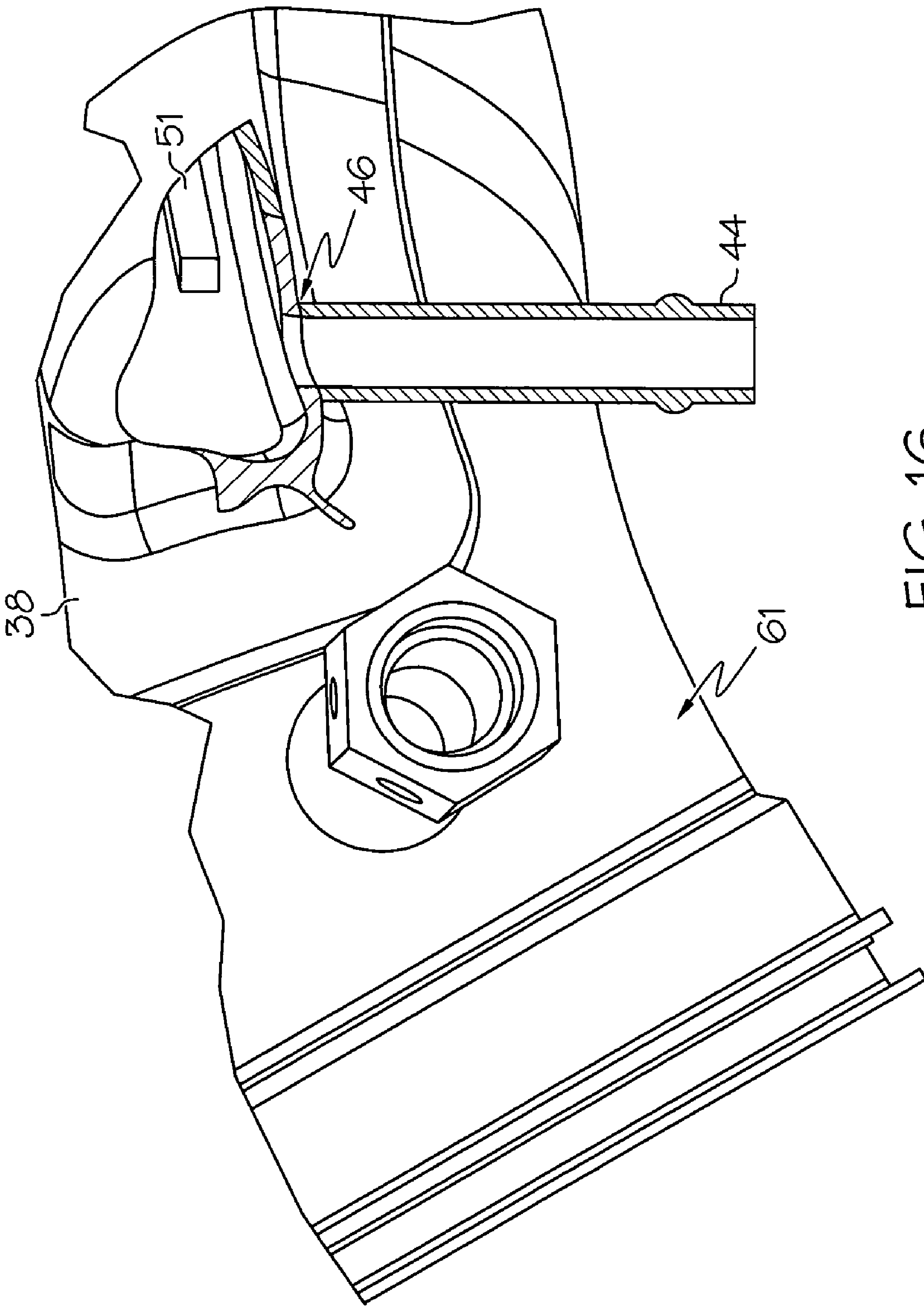


FIG. 16

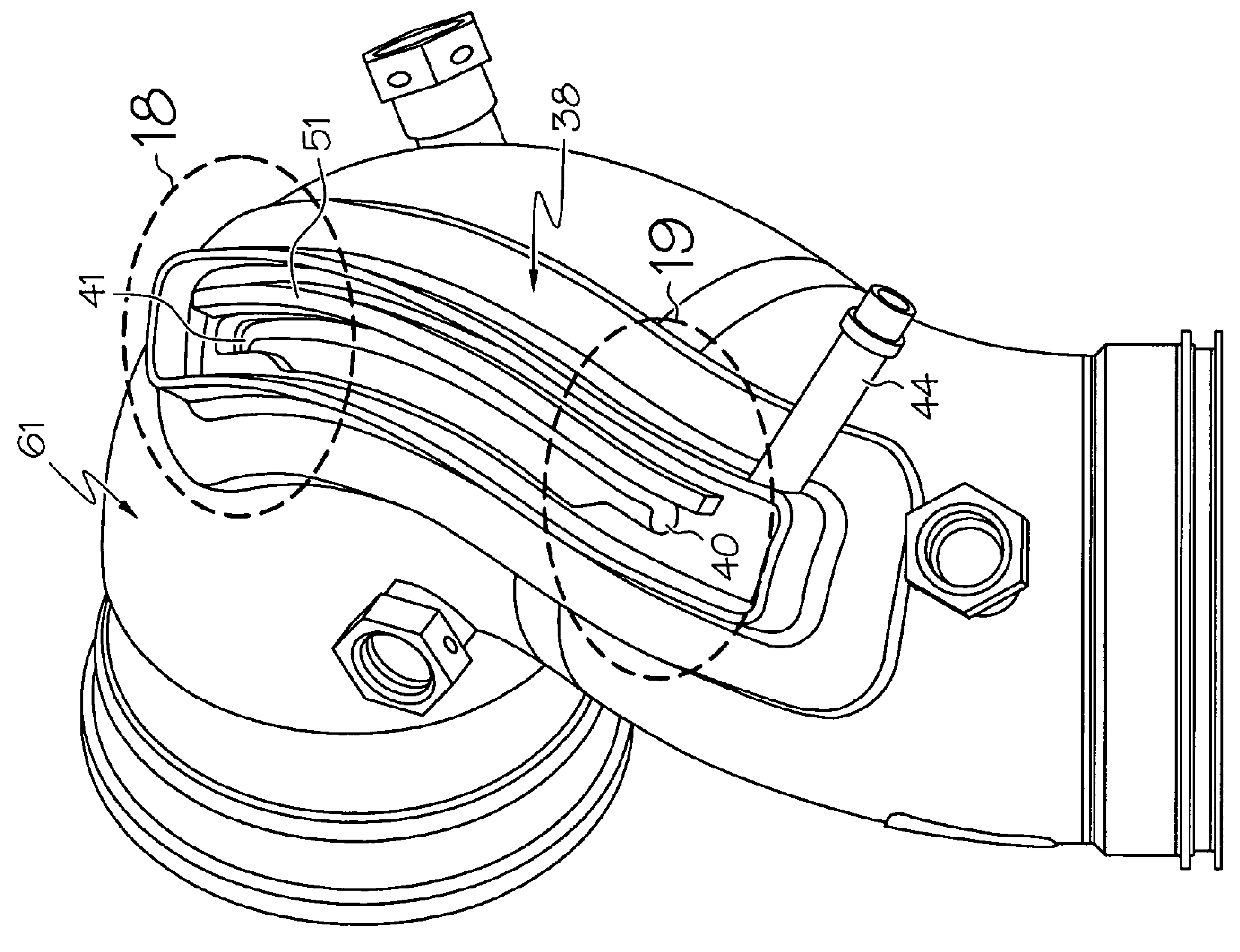


FIG. 17

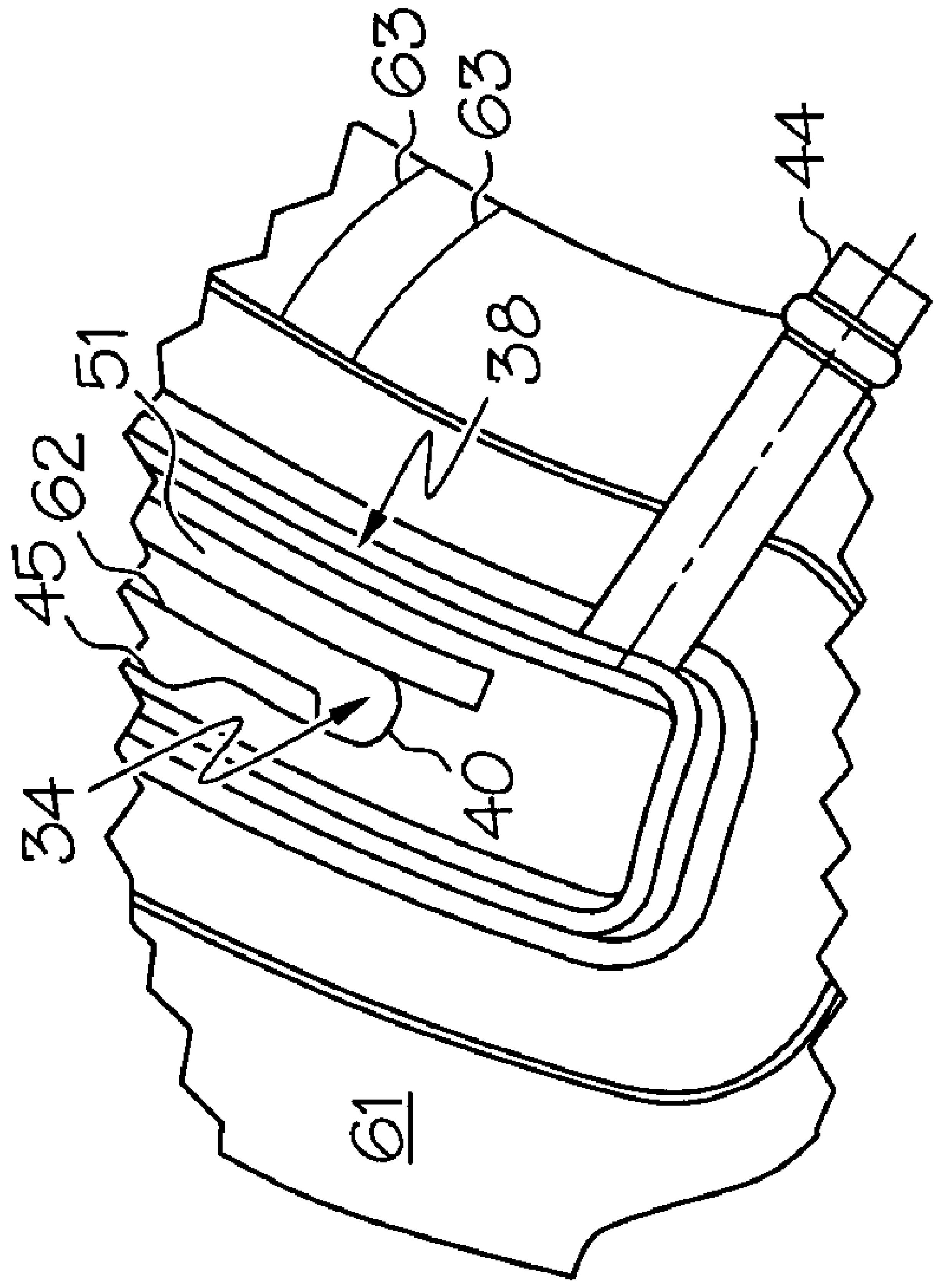


FIG. 19

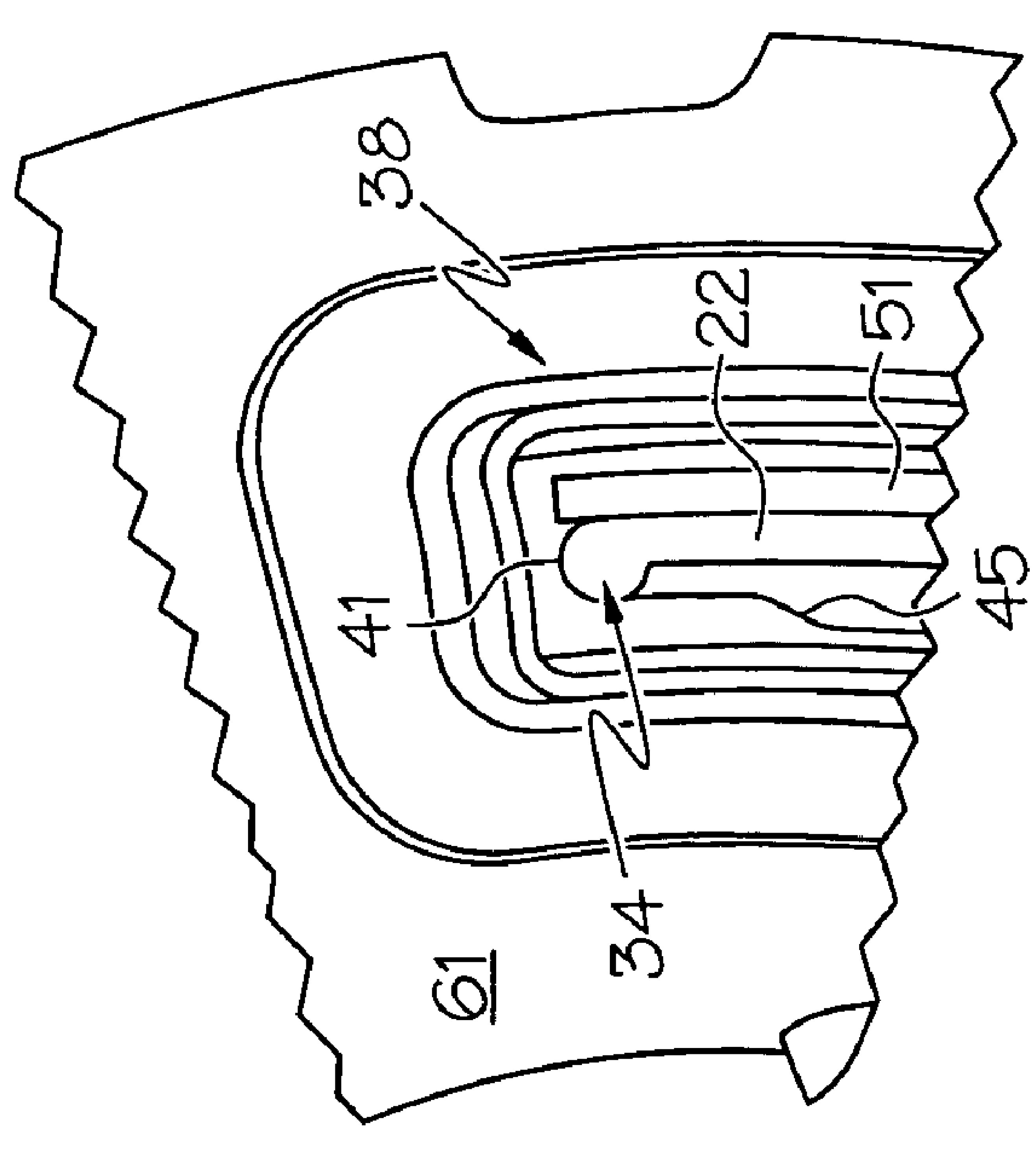


FIG. 18

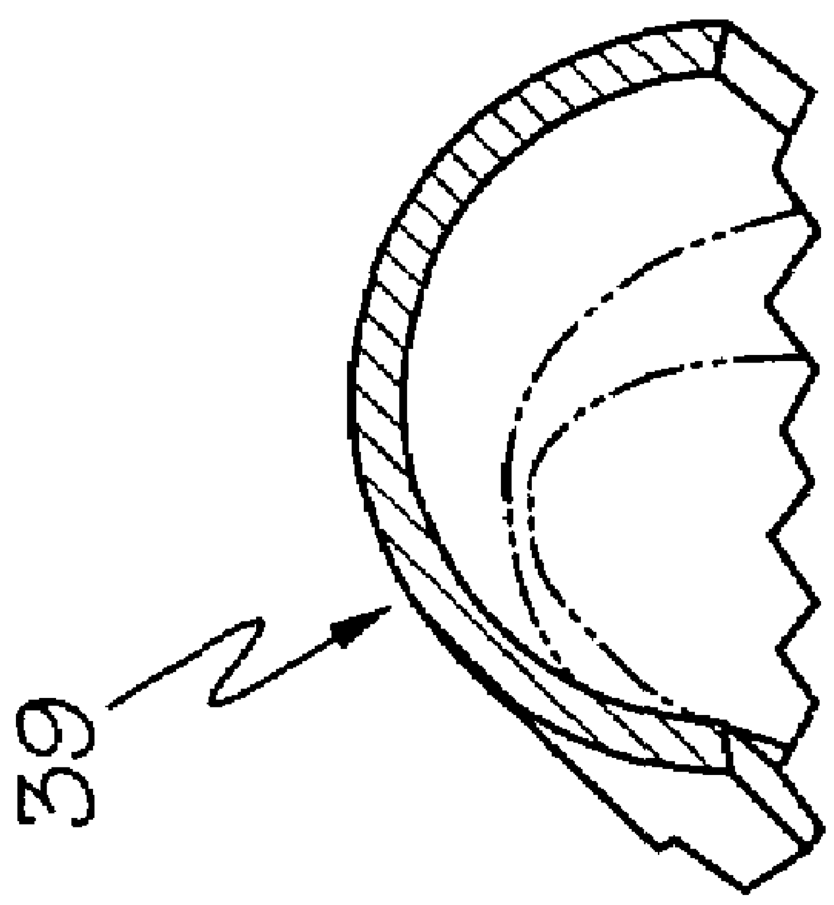


FIG. 21

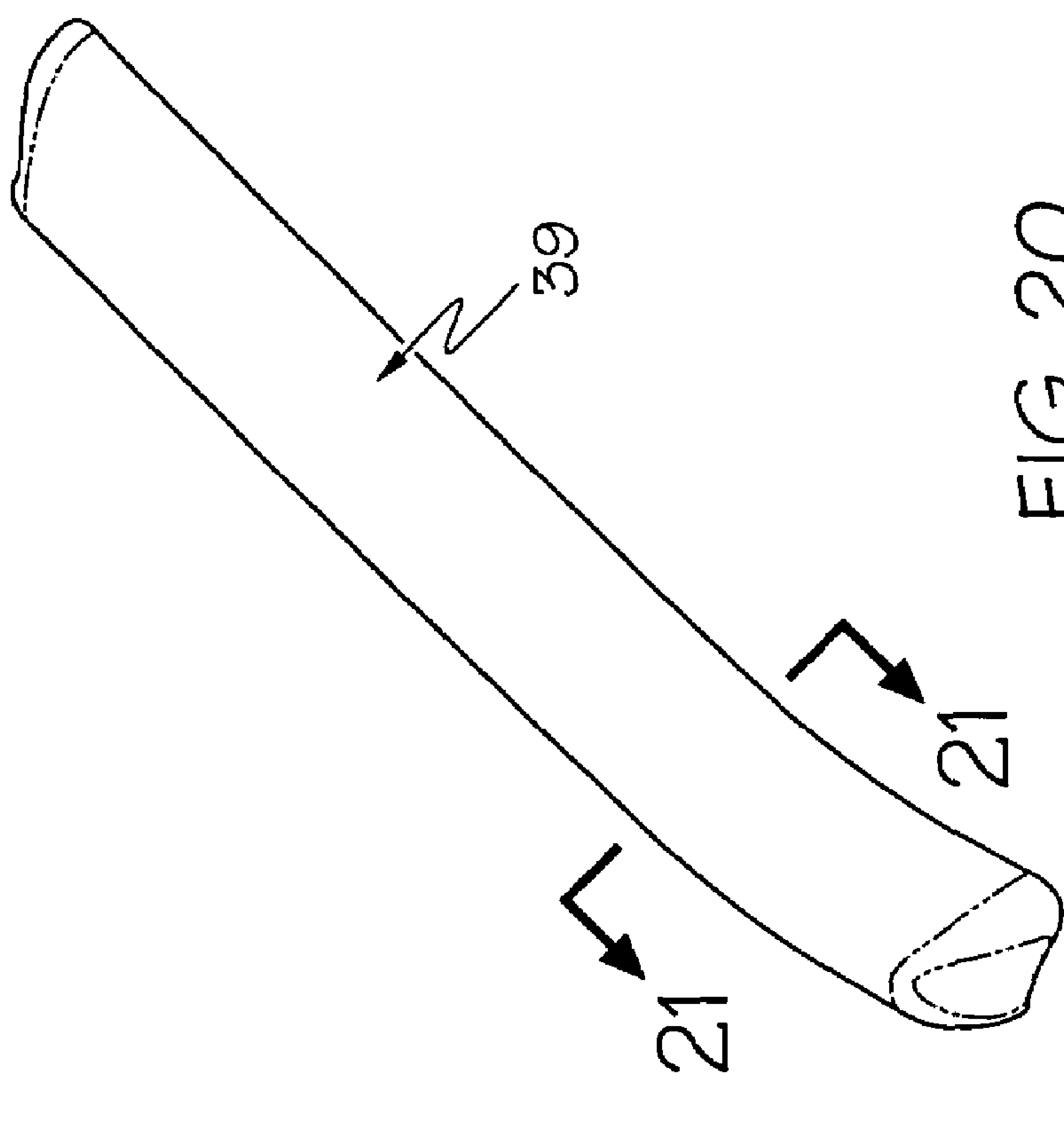


FIG. 20

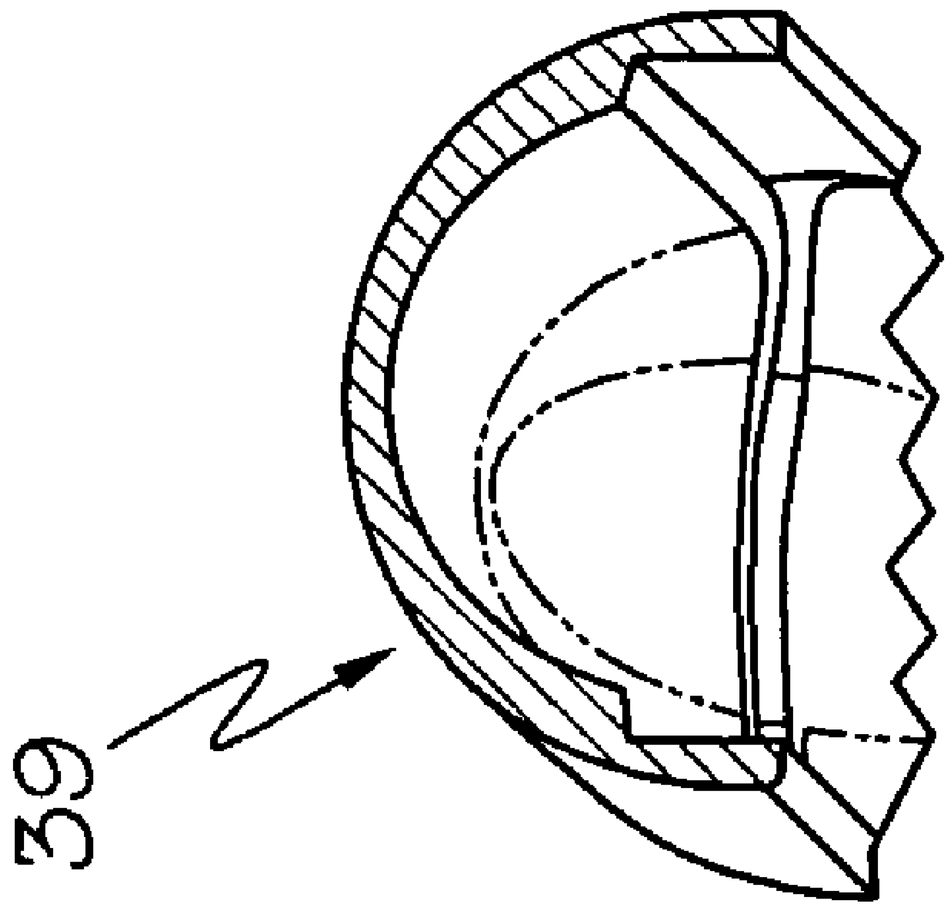


FIG. 23

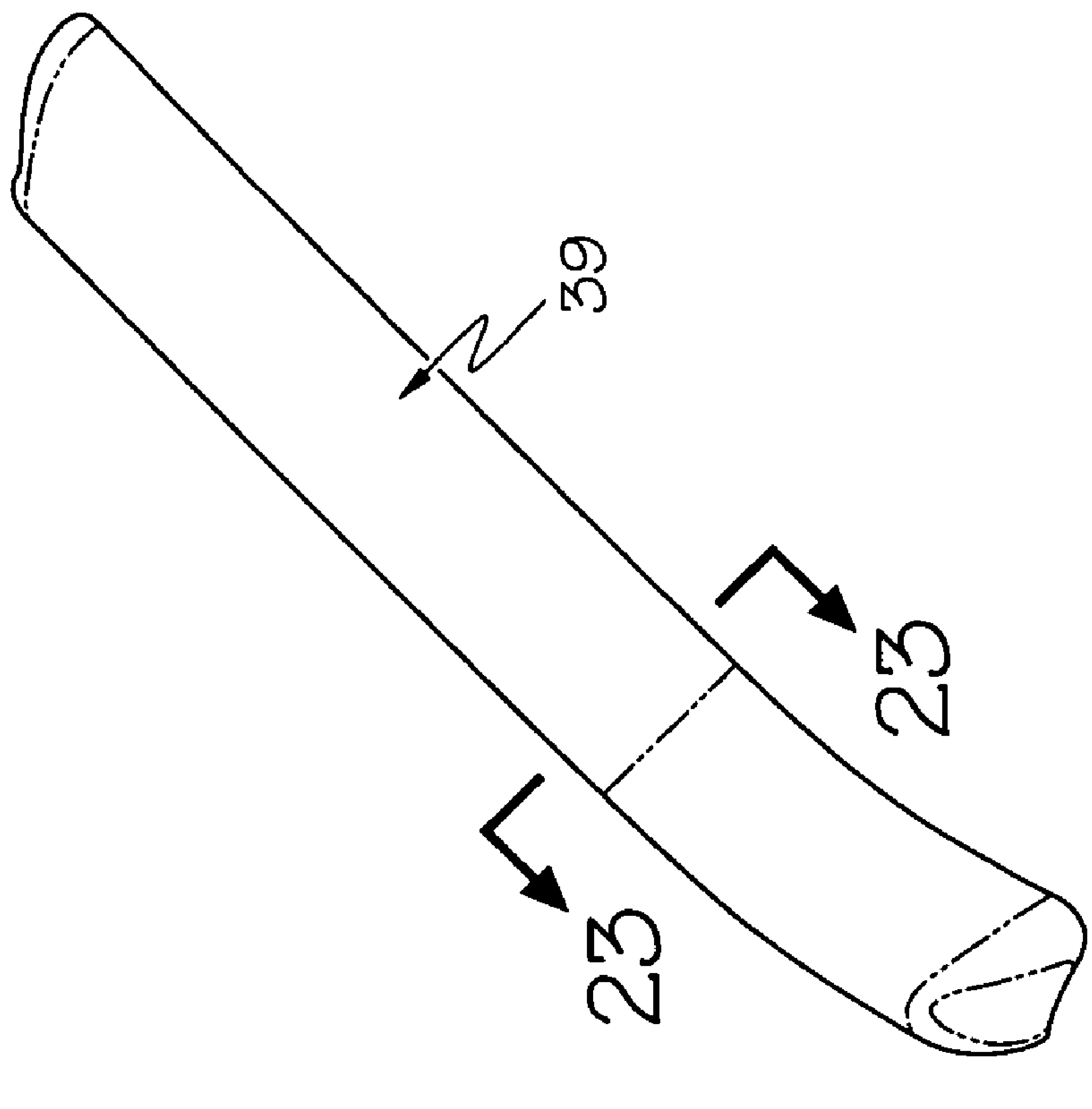


FIG. 22

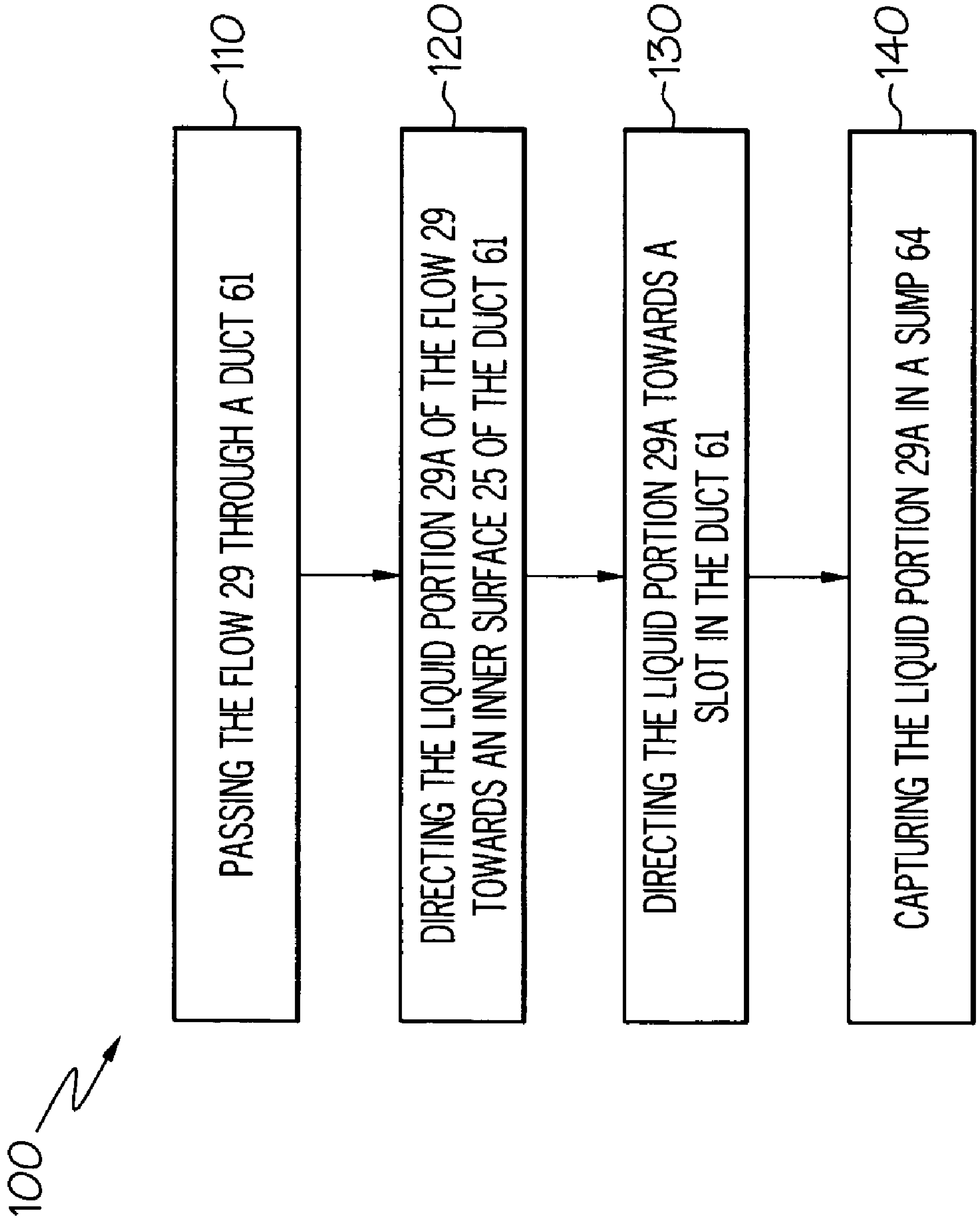

PASSING THE FLOW 29 THROUGH A DUCT 61
110
DIRECTING THE LIQUID PORTION 29A OF THE FLOW 29 TOWARDS AN INNER SURFACE 25 OF THE DUCT 61
120
DIRECTING THE LIQUID PORTION 29A TOWARDS A SLOT IN THE DUCT 61
130
CAPTURING THE LIQUID PORTION 29A IN A SUMP 64
140
100

FIG. 24

DUCT WALL WATER EXTRACTOR

GOVERNMENT INTERESTS

The invention was made with Government support under contract number DAAB07-03-D-B006-0013 awarded by the United States Air Force. The Government has certain rights in this invention.

CROSS-REFERENCE TO RELATED APPLICATION

The present application is related to issued U.S. Pat. No. 6,331,195, issued Dec. 18, 2001, which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention generally relates to liquid removal apparatus and, more particularly, to duct wall water extractors for aircraft environmental control systems.

Entrained moisture in environmental control systems (ECS) is transported through the conditioned air ducting at various points in the system. If this entrained moisture is not captured and drained away it can cause excessive moisture in the cockpit and/or avionics bay.

A dual scavenging separator is described in U.S. Pat. No. 4,179,273. The disclosed separator comprises a conical feature with an external spiral blade that swirls water droplets and particulates to the enclosing duct wall where they are drained away through slots in the wall into an external sump. A limited number of slots in the cone provide a flow path for the cleaned air. Although the described separator may capture entrained moisture, the tortuous and limited flow path area induces a significant pressure drop penalty for the cleaned air flowing through the device. The pressure drop results in reduced ECS capacity and/or engine efficiency for some aircraft applications.

A liquid separator assembly is described in U.S. Pat. No. 4,769,050. The disclosed assembly comprises two tubes (inlet and outlet), which are crimped, closed, perforated and housed within a surrounding enclosure. The air flow enters one tube, exits through the perforations into the enclosing chamber, and reenters the second tube through its perforations. The water droplets are separated from the air flow in the enclosing chamber and drained away. Unfortunately, this assembly also induces a significant pressure drop penalty caused by its tortuous and limited flow path area.

A liquid/gas separation device that does not require the air flow to go through a reduced airflow path is described in U.S. Pat. No. 5,302,301. In the disclosed separator, the water laden air flow enters an enlarged chamber tangentially, inducing a centrifugal force which drives the water droplets to the chamber wall and subsequently drain to the bottom of the chamber and out through a drain tube. The dried air moves to the center of the chamber where it is directed through a filter element that removes particulates prior to the air being discharged from the device. Unfortunately, the filter element induces a significant pressure drop penalty on the dried air flow. Additionally, this device requires a chamber with a large volume to allow the separation to occur. For some aircraft applications, there is limited space for devices to capture the entrained water due to the close packing of hardware and the large volume chamber may not be suitable.

As can be seen, there is a need for a water separator device that does not require a volume expansion or settling chamber to separate the water from the air stream. Because the amount of ECS airflow is critical, a water extraction device that does not excessively restrict the airflow is needed. Further, a water extractor that has a smaller and more compact design is needed.

SUMMARY OF THE INVENTION

In one aspect of the present invention, an apparatus for extracting a liquid portion from a flow comprises a duct adapted to receive the flow; and at least one slot positioned longitudinally along the duct.

In another aspect of the present invention, an apparatus for extracting a liquid portion from a flow comprises a duct adapted to receive the flow, the duct having a slot; a sump positioned longitudinally along the duct and in flow communication with the slot, the sump adapted to receive the liquid portion; and at least one ridge positioned on an inner surface of the duct and intersecting the slot.

In still another aspect of the present invention, an apparatus comprises a duct for receiving a liquid/gas mixture, the duct having a bend; a slot positioned on an outer side of the bend and positioned parallel to a duct axis of the duct; at least one ridge intersecting the slot; and a sump in contact with the duct and designed to enclose the slot, the sump adapted to receive a liquid portion of the liquid/gas mixture.

These and other features, aspects and advantages of the present invention will become better understood with reference to the following drawings, description and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of an environmental control system according to one embodiment of the present invention;

FIG. **2** is a perspective view of a liquid extractor according to one embodiment of the present invention;

FIG. **3** is another perspective view where the extractor of FIG. **2** has been rotated to view it from the inlet;

FIG. **4** is a cut-away rotated view of FIG. **2**;

FIG. **5***a* is a cross-sectional view through line **5-5** of FIG. **2**;

FIG. **5***b* is a cross-sectional view through line **5-5** according to another embodiment of the present invention;

FIG. **6***a* is a perspective view of a swirl device according to one embodiment of the present invention;

FIG. **6***b* is a side view of the swirl device of FIG. **6***a;*

FIG. **6***c* is a view through line **6***c*-**6***c* of FIG. **6***b;*

FIG. **7** is a cross-sectional view through line **7-7** of FIG. **2**;

FIG. **8***a* is a cross-sectional view of a portion of a duct according to one embodiment of the present invention;

FIG. **8***b* is a cross-sectional view of a portion of a duct according to another embodiment of the present invention;

FIG. **9** is a perspective view of a liquid extractor according to one embodiment of the present invention;

FIG. **10** is a view through line **10-10** of FIG. **9**;

FIG. **11** is a perspective view of a liquid extractor according to one embodiment of the present invention;

FIG. **12** is a close-up view of FIG. **11**;

FIG. **13** is a perspective view of a sump body according to one embodiment of the present invention;

FIG. **14** is a rotated view of FIG. **13**;

FIG. **15** is a cross-sectional view through line **15-15** of FIG. **14**;

FIG. **16** is a cut-away view of a portion of a liquid extractor according to one embodiment of the present invention;

FIG. **17** is a perspective view of a liquid extractor according to one embodiment of the present invention;

FIG. **18** is a close-up view of section **18** of FIG. **17**;

FIG. **19** is a close-up view of section **19** of FIG. **17**;

FIG. **20** is a perspective view of a sump cover according to one embodiment of the present invention;

FIG. **21** is a cross-sectional view through line **21-21** of FIG. **20**;

FIG. **22** is a perspective view of a sump cover according to another embodiment of the present invention;

FIG. **23** is a cross-sectional view through line **23-23** of FIG. **22**; and

FIG. **24** is a flow chart of a method of extracting a liquid portion from a flow according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The following detailed description is of the best currently contemplated modes of carrying out the invention. The description is not to be taken in a limiting sense, but is made merely for the purpose of illustrating the general principles of the invention, since the scope of the invention is best defined by the appended claims.

Broadly, the present invention provides liquid separation devices and methods for producing the same. Embodiments of the present invention may find beneficial use in many industries including aerospace, automotive, and electricity generation. Embodiments of the present invention may be beneficial in applications including aircraft environmental control systems (ECS) and heating ventilation and air-conditioning (HVAC) duct systems. Embodiments of the present invention may be useful in any liquid/gas separation application.

In one embodiment, the present invention may comprise a water extractor device having two primary features for removing entrained water from the interior wall of an ECS duct. The first primary feature may comprise a slot in the duct wall that is oriented longitudinally along the duct. An enclosing sump may be positioned on the outside of the duct and over the slot. Unlike the prior art, the longitudinal orientation may allow the extractor to fit in the aircraft better than a more traditional circumferential slot and housing or an extractor having a large volume chamber. Unlike the prior art that positions the extractor in a straight section of duct, the longitudinal slot of some embodiments of the present invention may be located on the outside of a bend in the duct, where inertial forces direct the entrained water. An upstream swirl device may or may not be used in conjunction with the slot.

The second primary feature may comprise one or more continuous ridges positioned on the interior duct wall surface. The ridges may be positioned to direct water on the duct wall to the slot where the water is extracted. The ridges may be single or multiple and may have gaps to direct the water to specific locations. Unlike the complicated flow path of the prior art, the water may flow along the ridges to the slot using Coanda effect on the downstream side of the ridges. Unlike the tortuous and limited flow path area of the prior art, the low profile ridges may not induce a significant pressure drop penalty.

In one embodiment, the present invention may provide a liquid extractor **60** for an environmental control system **70**, as depicted in FIG. **1**. The liquid extractor **60** may be positioned downstream from an existing ECS water separator **72**. The liquid extractor **60** may be in flow communication with an ECS duct system **74**. The liquid extractor **60** may be positioned upstream from a cockpit flow **76** and/or an avionics flow **78**.

The liquid extractor **60** according to an embodiment of the present invention is depicted in FIGS. **2-4**. The liquid extractor **60** may comprise a duct **61**, at least one slot **62** (see FIG. **3**), at least one ridge **63** and a sump **64**. The duct **61** may be designed to receive a flow **29** comprising a liquid/gas mixture. The slot **62** may be positioned longitudinally along the duct **61**. The ridge **63** may be positioned on an inner surface **25** of the duct **61** and designed to direct a liquid portion **29***a* (see FIG. **3**) of the flow **29** towards the slot **62**. The sump **64** may be positioned radially outward from the slot **62** and designed to receive the liquid portion **29***a*. Although the embodiments of the liquid extractor **60** depicted in the figures include at least one ridge **63**, it is contemplated that the invention may also lack the ridges **63**.

The duct **61**, such as, but not limited to, an ECS duct, may comprise a tube shaped structure having an inlet **26** and an outlet **27**. The dimensions of the duct **61** may vary and may depend on the application. For a non-limiting example, the duct **61** may have a length of about 10.0 inches and a diameter of about 3.0 inches for some ECS applcations. The duct **61** may comprise various materials including, but not limited to, sheet metal and plastic. For some applications, the duct **61** may comprise aluminum. The inlet **26** may be designed to receive the flow **29**. The flow **29** may comprise various liquid/gas mixtures, such as a water/air mixture or an oil/air mixture.

The duct **61** may include a bend **28**. As the flow **29** passes through the bend **28**, inertial forces may direct the liquid portion **29***a* (see FIG. **3**) of the flow **29** to be thrown toward an outer side **33** of the bend **28** and onto the inner surface **25** of the duct **61**. For some applications, the duct **61** may comprise a straight cylindrical member having no bends (not shown) and the duct **61** may be positioned such that gravity may direct the liquid portion **29***a* of the flow **29** towards the inner surface **25** of the duct **61**.

The duct **61** may include a swirl device **32** (see FIGS. **6***a*-**6***c*), such as a static swirl vane. The swirl device **32** may be positioned upstream from the slot **62**. The swirl device **32** may impart a centrifugal swirl on the flow **29**. In FIGS. **3** and **4** the swirl is in a counter-clockwise direction looking downstream. The centrifugal swirl may cause the heavier liquid portion **29***a* (e.g. entrained water) of the flow **29** to be separated from a lighter portion (not shown) (e.g. air) of the flow **29**. The centrifugal swirl may throw the entrained water downstream and outward towards the inner surface **25** of the duct **61**. Embodiments of the liquid extractor **60** may comprise the bend **28**, the swirl device **31**, both the bend **28** and the swirl device **31**, or neither the bend **28** nor the swirl device **31** to direct the liquid portion **29***a* of the flow **29** towards the inner surface **25** of the duct **61**.

The liquid extractor **60** may include at least one slot **62**, as depicted in FIG. **3**. The slot **62** may allow for capture of the liquid portion **29***a* of the flow **29**, which may be traveling on the inner surface **25** of the duct **61**. The slot **62** may comprise a slit through the wall of the duct **61** and may be oriented longitudinally along the duct **61**. For some applications, the slot **62** may be positioned lengthwise along the duct **61** and parallel to a duct axis **30**, as depicted in FIG. **3**. For some applications, the slot **62** may include a keyhole **34** (see FIG. **3**) positioned at an upstream end **40** and/or a downstream end **41** (see FIG. **18**) of the slot **62** to reduce the stress gradient of the duct **61** resulting from the flow **29** and associated pressure.

The dimensions of the slot **62** may vary with application. Computational fluid dynamics analysis (CFD) may be useful for determining the dimensions of the slot **62** for some applications. By way of non-limiting example, some applications may have a slot **62** comprising a slot width **31** (see FIG. **5***a*) of less than about 0.25 inch. The slot width **31** may be, but not limited to, approximately 0.15 inch for some aircraft applications. For some applications, turbulence within the sump **64** may be proportional to the slot width **31**. In other words, the larger the slot width **31**, the greater the turbulence within the sump **64**. Excessive sump turbulence may result in the liquid portion **29***a* reentering the duct **61** from the sump **64** and a reduction in extractor efficiency. The length of the slot **62** may vary and may depend on factors including the diameter of the duct **61**. For some applications, the length of the slot **62** may be about equal to or greater than the diameter of the duct **61**. For example, a duct **61** having a 3.0-inch diameter may include a slot **62** having a length between 4 and 5 inches.

The slot **62** may be positioned on the outer side **33** of the bend **28**, for applications including the bend **28**. The slot **62** may be positioned downstream from the swirl device **32**, for applications including the swirl device **32**. For some applications, the duct **61** may comprise more than one slot **62** and the slots **62** may be positioned axially in-line with respect to the duct axis **30**. Alternatively, the slots **62** may be positioned parallel to each other about the circumference of the duct **61**. As a third alternative, the slots **62** may be positioned parallel and axially staggered. The number and positioning of the slots **62** may vary with application and may depend on factors including the dimension of the duct **61** and the composition of the flow **29**.

The liquid extractor **60** may include at least one ridge **63**, as depicted in FIG. **7**. The ridge **63** may comprise a ridge-shaped structure that extends radially inward from the inner surface **25** of the duct **61**. A radial height **35** of the ridge **63** may be between about 0.050 inches and about 0.100 inches. The radial height **35** may be such that the ridge **63** produces minimal resistance to the flow **29** in the duct **61** and such that the ridge **63** directs the liquid portion **29***a* of the flow **29** towards the slot **62**. The ridge **63** may be formed by various methods. For example, weld penetration techniques may be used to provide the ridge **63**. Alternatively, the ridge **63** may comprise a strip of metal attached to the inner surface **25** of the duct **61**. The method of providing the ridge **63** may depend on manufacturing preference.

Some embodiments of the liquid extractor **60** may comprise two or more ridges **63** parallel to one another, forming a group of ridges **63**. Ridges **63** within a group may be spaced axially from one another by a minimum axial distance **42** of about 0.35 inches, as depicted in FIG. **7**. Some embodiments of the present invention may comprise more than one group of ridges **63**. For example, the liquid extractor **60** may comprise one group of ridges **63** towards the upstream end **40** of the slot **62** and another group of ridges **63** towards the downstream end **41** of the slot **62**. For some embodiments, for example when the duct **61** has a bend **28**, the groups of ridges **63** may not be parallel to one another. The number and positioning of the ridge(s) **63** may vary with application and may depend on factors including the dimensions of duct **61** and the length of the slot **62**. For some ECS applications, the liquid extractor **60** may comprise less than about ten ridges.

At least one ridge **63** may intersect the slot **62**, as depicted in FIGS. **3** and **11**. For some embodiments, the ridge **63** may intersect the slot **62** at a position at least about 2.0 inches upstream from the downstream end **41** of the slot **62**. The ridge **63** may intersect the slot **62** at an angle (ridge/slot angle **36**) less than or equal to about 90 degrees, as depicted in FIGS. **8***a* and **8***b*. The ridge **63** may run circumferentially along the inner surface **25** such that the ridge **63** may be about perpendicular to the duct axis **30**, as depicted in FIG. **8***a*. Alternatively, the ridge **63** may have a swirl orientation relative to the duct axis **30**, as depicted in FIG. **8***b*. The ridge **63** may direct the liquid portion **29***a* to the slot **62** where it may be captured. Some embodiments may further include at least one non-slot-intersecting ridge (upstream ridge **63***b*) upstream from the slot **62**, as depicted in FIGS. **9** and **10**. The upstream ridge **63***b* may concentrate the liquid potion **29***a* of the flow **29**.

A gap **43**, as depicted in FIG. **12**, may be incorporated into the ridge **63** and/or **63***b* at a strategic position, which allows the flow **29** to redirect the liquid portion **29***a* away from the ridge **63**, **63***b* to another ridge(s) **63**, **63***b* or the slot **62**.

The ridge **63**, **63***b* may be angled with respect to the flow **29**. The ridge **63**, **63***b* and the surface of the flow **29** may form an angle (ridge/flow angle **37**) of between about 10° and about 70°, as depicted in FIGS. **8***a* and **8***b*. For some applications, the ridge/flow angle **37** may be less than about 60°. For applications including more than one ridge **63**, **63***b*, the ridge/flow angle **37** may or may not be the same for each ridge **63**, **63***b*. The ridge/flow angle **37** may vary with application and may depend on factors including the diameter of the duct **61** and the velocity of the flow **29**.

Due to the low radial height **35** (e.g. about, but not limited to, 0.060 inches for some ECS applications), the ridge **63**, **63***b* may produce minimal resistance to air flow (flow **29**) in the duct **61**. The ridge **63**, **63***b* may capture the liquid portion **29***a* (e.g. water) on the downstream side of the ridge **63**, **63***b* due to the low pressure zone created there, and the liquid portion **29***a* may run along the ridge **63**, **63***b* due to the relative angle of the air flow (ridge/flow angle **37**). The liquid portion **29***a* running along the ridge **63** may pass through the slot **62** and enter the sump **64**.

The sump **64** of the liquid extractor **60** may comprise a structure having a sump cavity **47** adapted to receive the liquid portion **29***a* of the flow **29**, as depicted in FIGS. **5***a* and **5***b*. The sump **64** may comprise a structure that encloses the slot **62** such that the liquid portion **29***a* passing through the slot **62** from the duct **61** may enter the sump cavity **47**. The sump **64** may be positioned radially outward from the slot **62** and attached to the duct **61**. The sump **64** may comprise a body member **38** and a cover member **39**, as depicted in FIGS. **2** and **4**.

The body member **38**, as depicted in FIGS. **13-15**, may comprise a structure having a drainage orifice **46** and an opening **45**. The drainage orifice **46** may be in flow communication with a drain boss **44**, as depicted in FIG. **16**. During assembly, the opening **45** may be positioned over the slot **62**, as depicted in FIGS. **17-19**. The opening **45** may be in flow communication with the slot **62** such that the liquid portion **29***a* the passes from the slot **62**, through the opening **45** and into the sump cavity **47**, as depicted in FIG. **5***a* and **5***b*.

The dimensions of the opening **45** may vary with application and may depend on the dimensions of the slot **62**. A first edge distance **48***a* measured from the slot **62** to a first inner wall **49** of the body member **38** may be, but not limited to, between about 0.20 inches and about 0.35 inches, as depicted in FIG. **5***a*. For some ECS applications, the first edge distance **48***a* may be approximately 0.25 inches. A second edge distance **48***b* measured from the slot **62** to a second inner wall **50** of the body member **38** may be, but not limited to, between about 0.25 inches and about 0.50 inches, as depicted in FIG. **5***a*. For some ECS applications, the second edge distance **48***b* may be approximately 0.38 inches. The second edge distance **48***b* may be large enough that the liquid portion **29***a* does not reenter the duct **61**, but instead exits the sump cavity **47** through the drainage orifice **46**.

The body member **38**, as depicted in FIGS. **5***a* and **5***b* may include a retaining wall **51**. The retaining wall **51** may comprise a structure positioned within the sump cavity **47** and along the length of the slot **62**. A gutter **52** may be created between the retaining wall **51** and an interior surface **53** of the sump **64**. The gutter **52** may capture, retain, and direct the liquid portion **29**a towards the drainage orifice **46**. For some applications, the retaining wall **51** may allow the second edge distance **48**b to be reduced. For example, a second edge distance of about 0.38 inch may be reduced to approx 0.28 inch when the retaining wall **51** is included.

The cover member **39**, as depicted in FIGS. **20-23**, may comprise a structure adapted to attach to the body member **38**. In some embodiments, the cover member **39** may be designed to be welded to the body member **38**, as depicted in FIGS. **5**a, **20** and **21**. In an alternate embodiment, the cover member **39** may be designed to be brazed to the body member **38**, as depicted in FIGS. **5**b, **22** and **23**. In another alternate embodiment, the cover member **39** may be integral to the body member **38**. The design of the cover member **39** and the body member **38** may depend on manufacturing preference.

A method **100** of extracting a liquid portion from a flow is depicted in FIG. **24**. The method **100** may comprise a step **110** of passing the flow **29** through a duct **61**, a step **120** of directing the liquid portion **29**a of the flow **29** towards an inner surface **25** of the duct **61**, a step **130** of directing the liquid portion **29**a towards a slot in the duct **61** and a step **140** of capturing the liquid portion **29**a in a sump **64**. The step **110** of passing the flow **29** may comprise passing a water/air mixture through a duct of an ECS. The step **120** of directing the liquid portion **29**a towards an inner surface **25** of the duct **61** may comprise imparting a centrifugal swirl on the flow **29**. The step **120** may comprise passing the flow **29** through a bend **28** in the duct **61** such that inertial forces direct the liquid portion **29**a to be thrown toward an outer side **33** of the bend **28** and onto the inner surface **25**. The step **130** of directing the liquid portion **29**a towards a slot in the duct **61** may comprise running the liquid portion **29**a along at least one ridge **63** on the inner surface **25** of the duct **61**. The step **140** of capturing the liquid portion **29**a in a sump **64** may comprise flowing the liquid portion **29**a into a gutter **52** of the sump **64**.

As can be appreciated by those skilled in the art, the present invention provides improved liquid extractors. The longitudinal sump configuration allows embodiments of the present invention to be effectively used in envelope constrained applications. The slot and ridge design of the present invention provides liquid extractors that can be used in straight and/or elbow sections of a duct.

It should be understood, of course, that the foregoing relates to exemplary embodiments of the invention and that modifications may be made without departing from the spirit and scope of the invention as set forth in the following claims.

We claim:

1. An apparatus for extracting a liquid portion from a flow comprising:

a duct adapted to receive said flow;

at least one slot positioned longitudinally along said duct; and

at least one ridge positioned on an inner surface of said duct and adapted to direct said liquid portion to said slot.

2. The apparatus of claim **1**, wherein said ridge intersects said slot.

3. The apparatus of claim **1**, wherein said ridge and a surface of said flow forms a ridge/flow angle between about 10° and about 70°.

4. The apparatus of claim **1**, further comprising a sump positioned radially outward from said slot and attached to with said duct.

5. The apparatus of claim **1**, further comprising a swirl device positioned upstream from said slot.

6. The apparatus of claim **1**, wherein said duct has a bend and said slot is positioned on an outer side of said bend.

7. The apparatus of claim **1**, further comprising at least one upstream ridge positioned on said inner surface and upstream from said slot, said upstream ridge having a gap.

8. The apparatus of claim **1**, wherein said apparatus comprises at least two slots.

9. The apparatus of claim **8**, wherein said two slots are axially aligned.

10. An apparatus for extracting a liquid portion from a flow comprising:

a duct adapted to receive said flow, said duct having a slot;

a sump positioned longitudinally along said duct and in flow communication with said slot, said sump adapted to receive said liquid portion; and

at least one ridge positioned on an inner surface of said duct and intersecting said slot.

11. The apparatus of claim **10**, wherein said ridge intersects said slot such that a ridge/slot angle of less than or equal to about 90 degrees is formed.

12. The apparatus of claim **10**, wherein said apparatus comprises at least two slots positioned parallel to each other.

13. The apparatus of claim **10**, wherein said ridge and a surface of said flow forms a ridge/flow angle of less than about 60°.

14. The apparatus of claim **10**, wherein said sump includes a retaining wall wherein a gutter is formed between said retaining wall and an interior surface of said sump.

15. The apparatus of claim **10**, wherein said sump includes a drainage orifice.

16. The apparatus of claim **10**, wherein said ridge has a radial height of between about 0.050 inches and about 0.100 inches.

17. The apparatus of claim **10**, wherein said slot includes at least one keyhole.

18. The apparatus of claim **10**, wherein said slot has a slot width of less than about 0.25 inch.

19. An apparatus comprising:

a duct for receiving a liquid/gas mixture, said duct having a bend;

a slot positioned on an outer side of said bend and positioned parallel to a duct axis of said duct;

at least one ridge intersecting said slot; and

a sump in contact with said duct and designed to enclose said slot, said sump adapted to receive a liquid portion of said liquid/gas mixture.

20. The apparatus of claim **19**, wherein said sump is in flow communication with a drain boss.

21. The apparatus of claim **19**, wherein said apparatus comprises at least two ridges positioned parallel to each other.

22. The apparatus of claim **19**, further comprising at least one upstream ridge positioned upstream from said slot.

23. The apparatus of claim **19**, wherein said duct is an environmental control system duct and said liquid/gas mixture comprises a water/air mixture.

24. The apparatus of claim **19**, wherein said ridge and said slot form a ridge/slot angle of less than about 90°.

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